

PHYSICAL ATTACK

IW 140

OPR: Captain Winston A. Gould

DESCRIPTION: This lesson discusses the principles of physical attack in Information Warfare.

METHODOLOGY: Informal Lecture/1.5 Hours

OBJECTIVE: The objective of this lesson plan is for each student to comprehend role of physical attack in Information Warfare.

1. **SAMPLES OF BEHAVIOR:** Explain the relationship between physical attack and U. S. Air Force Information Warfare doctrine.
2. Understand how targeting principles contribute to effective physical attack of Information Warfare targets.
3. Discuss various physical attack capabilities and how they are integrated within Information Warfare.

REQUIRED READINGS:

1. "Hardcore Hard Kill: Seeds of a New SEAD". Zach Lum. *Journal of Electronic Defense*. Association of Old Crows. 1997. Instruction Circular Pages 120-H-1 through 220-H-7.
2. IW 140 readings in the Instruction Circular.

Hardcore Hard Kill: Seeds of a New SEAD

Zach Lum, Journal of Electronic Defense, February, 1997

The mourning period is over. For the past several years, our treatment of the suppression of enemy air defenses (SEAD) mission has focused on the scrapping of dedicated EW platforms. After all, the US EW community has had few recognizable icons around which to form its identity; losing the trademark "Raven" and "Wild Weasel" call signs is akin to losing a middle and last name. But JED can write only so many elegies to SAM killers past.

Here's a brief, uninflected summary for those who still need a refresher:

Yes, the vaunted F-4G Wild Weasel has retired to a "maintenance and regeneration center" at an Arizona Air Force base — it's gone to the boneyard. Its replacement, a single-seat F-16CJ equipped with the podded HARM (the AGM-88 High Speed Anti-Radiation Missile) Targeting System (HTS), is, in a one-to-one comparison, an admittedly less ambitious, less proficient lethal-SEAD platform; it was devised originally as an interim to an F-15-based Weasel follow-on that, when the bill arrived, the Air Force decided it couldn't afford. Simultaneously, the Pentagon decided it couldn't afford to maintain two fleets of upgrade-needy support-jamming aircraft, sounding the death knell for the EF-111. The Air Force has now culled the active Raven fleet to 12. The woeful dozen will serve until 1999 to smooth the Air Force transition to the Navy's EA-6B Prowler, a new concept in joint service but the last of a dying breed in TACAIR.

Bemoaning the status quo is pointless because those lost capabilities, in those incarnations, are not the solutions of the future. Once the EA-6B reaches its inevitable retirement, the US will probably never field a dedicated, manned platform for either support jamming (nonlethal SEAD) or lethal suppression again. And this is not necessarily a bad thing. Technologies emerging along the command and control (C2) warfare front offer the possibility of radically redefining, even revolutionizing, SEAD. What the EW community should be lamenting now is the fact that the services and the Pentagon have been reluctant to make the necessary investments to take SEAD across the existing capability gap and into the 21st century.

PREEMPTIVE PRESUMPTIONS

The termination of older, dedicated EW assets has in some ways injected new life into SEAD thinking by liberating the concept from its moribund attachment to a particular platform and mission. What has emerged in the fallout is a different path for the conduct of air-defense suppression, one that has a decidedly hardcore hard-kill slant — and perhaps a discomfitting focus on non-EW or marginal EW disciplines.

The new philosophy is "preemptive destruction," in deliberate counterpoint to the "reactive suppression" mission that has characterized SEAD from the early air campaigns

in Vietnam to the present deployment of F-16 HTS aircraft to Iraq. As its name implies, reactive suppression is a reflexive response. Flying escort for a strike package, the F-16 HTS's task is to dampen, with a volley of radar-homing HARMs, any hostile SAM activity that lights up along the ingress or egress routes. Hitting the target is of secondary importance, and inflicting permanent damage "is just gravy," in the words of one former Weasel pilot (with its rather diminutive warhead, the HARM is a good antenna killer but rarely puts a SAM site out of action permanently). The intent is to suppress SAM activity for the duration of the one mission. Forcing the SAM radars to shut off to escape the HARM's homing seeker is a successful outcome.

The drawback to reactive suppression is its impermanence. With a new antenna, a HARM-struck sight may be back in action the next day. Iraq, despite suffering the complete incapacitation of its air defenses during the Gulf War, has been able to rapidly rebuild its surface-to-air menace, as attested to by encounters with NATO aircraft over the no-fly zone in past months. Iraq could perform this feat in large part because its SAM sites were damaged, but not completely destroyed, by the coalition air campaign.

To correct this deficiency, the new SEAD mentality would turn SAM hunting into a campaign-level mission. Counterbalancing the constriction of the force structure and its distillation to multirole platforms, preemptive-destruction solutions would ensure an enduring attrition of enemy air defenses. Instead of reacting to threats as they come on the air, SEAD assets would target them beforehand, perhaps in the hour or half-hour before the strike, to blast a clean corridor to the target — thus the "preemptive" prefix. "And it's 'destructive' in the fact that [when] it hits, we understand it's dead. There's no more bringing in an extra antenna," explained Maj Don Lundie, the electronic attack branch chief at the USAF Air Combat Command/DRFA, referring to the more conventional hard kill — the extra tonnage of warhead — the SEAD weapon would inflict.

Of course, while the preemptive mission is intended to reduce the overall requirements for reactive SEAD, experts agree that some HARM-shooting capability will always be needed for the inevitable stray threats, the ones that escape the net.

MADDENING MOBILITY



The mobile threat is the focus of attention of current SEAD efforts. (File photo)

These elusive threats will undoubtedly be the mobile ones. For the Air Force's Air Combat Command (ACC), which has taken the lead in formulating a requirement for preemptive SEAD, the mobile threat is proving to be the crux of the problem. The fixed, easily pinpointed C2 and SAM assets in an air-defense network — the early warning and coastal surveillance radars and huge, concrete-based coordination/communications centers — are targets the Air Force believes it already has the capacity to tackle: they seem well suited for the new generation of INS/GPS weapons like JDAM or JSOW or, if the target is of high value, even a cruise missile. But SAMs on wheels, like the Iraqi Scuds that gave US hunter/killer strike aircraft such conniptions during the Gulf War, require a whole new targeting and weapons system approach. As seen by one Pentagon requirements official close to SEAD developments, "We'll need dominating battlefield awareness to deal with the mobile SAMs — sensors, fusion and dissemination — the right information to the right people at the right time. We need sensors and architectures that provide 'in time' targeting whether the information comes from off-board, manned aircraft or UAVs."

This seems to be the prevailing opinion within Air Force procurement and planning circles — the information revolution will sweep SEAD to the needed level of capability along with every other targeting discipline. In these austere budget climes where the Air Force is trying to push through ambitious new fighter platforms like the F-22 and the Joint Strike Fighter, folding the evolution of SEAD into the compass of sensor fusion, C2 warfare and real-time information to the cockpit has both strategic and financial allure. But is this determination in some part a product of self-deception, an excuse to avoid the pressing need to make some specific SEAD technology investments? After all, the hitch in the scenario is that this nirvana of sensor interconnectivity is, like nirvana, a long way off. And the mobile threat is a very immediate one.



The F-16 now owns the HARM mission. To be truly effective, it needs off-board cues from systems like Rivet Joint. (Texas Instruments photo)

"They [mobile SAMs] can come up, fire and then shut down, and then move before we get to them. And all these visions of this information being passed down rapidly in real time to the cockpit, I don't think we're really taking a hard look there," said Major Lundie. Indeed, off-board cueing of shooters by sensor platforms is in a very nascent stage. This past summer saw the first test of the Air Force's Integrated Data Modem (IDM), a new, digital datalink for F-16s, as a threat-cueing pipeline between RC-135 Rivet Joint and F-16 HTS aircraft patrolling Iraq. With its powerful ELINT systems, the Rivet Joint can detect,

locate and characterize threat systems much faster and much more accurately than the HTS, but the IDM, while better than previous voice prompting between the two aircraft types, is limited in the amount of this specialized data it can distribute in the requisite time frames. The upcoming Link 16 will provide truer all-source fusion, but this system is still a long-term prospect. "I think we have a long ways to go there. We're just starting to get our feet wet in this area...passing information on one or two emitters under the best of conditions, when in fact what we need to do is be able to track multiple targets in a very dense environment and locate them precisely and very rapidly," said Major Lundie. What the Air Force needs in the interim, according to Lundie, is a "migration pattern" that will produce an autonomous preemptive capability and retain an autonomous reactive suppression mission around which the new architecture can build.

CONCEPTS

Speed and precision — these are the two qualities that such an autonomous mobile-SAM targeting solution needs in extremis. Just how much of both was the subject of a two-year concept exploration performed, at the ACC's behest, by the Air Force's Lethal SEAD Office at Eglin AFB, FL. According to Leo Rose, chief engineer at the office, the study is basically complete, with some fine tuning remaining in modeling and simulation, and the ACC should have the report in hand within a couple of months. The baton passed, the ACC will then have to decide whether to "POM" for the money and set some sort of solution rolling toward a Milestone 1.

The study had two main thrusts, according to Rose. First, his group analyzed and characterized the critical features of the target set, the imprecisely located mobile air-defense unit. The results are classified, but are known to include, for instance, the types of threats, over-land speed, the reaction time, emission times, frequency coverage, vehicle dispersal — "in other words, what is it that the threat can and cannot do," explained Rose. Next, the study team fed the data to 63 contractors to suggest achievable, off-the-shelf technology solutions. After acquiring some simulations and models, the office has now produced a range of about four preemptive SEAD concepts that it believes offer viable approaches for attacking mobile SAMs with a very low level of attrition for the attacker.

The four systems solutions purposefully varied in the complexity of the targeting system and the associated complexity (or lack thereof) in the weapon, said Rose, to emphasize the point that "preemptive destruction was not a targeting solution problem. It was a targeting/weapon solution problem."

The first concept, for example, posited the use of a relatively "dumb" weapon, an INS/GPS-guided munition without a terminal seeker. Its associated targeting solution, therefore, had to have a very accurate target location error. The next three solutions proposed weapons with increasingly capable seeker search capabilities over increasingly large areas of uncertainty, which meant the accompanying targeting systems could be less and less accurate. For each of the concepts, the study looked at development risk, technology risk, schedule (maturity) and cost for development, production and integration

onto the selected platform. "What we presented was four very realistic ways of solving the problem, but those four really cover the gamut...of systems solutions you can employ....Do you want to put all your money in a targeting system? Perhaps you do very minor modifications to existing weapons...to match that....That's kind of the flavor of the solutions that we've presented to them [ACC]," said Rose.

NUTS AND BOLTS

Specifics on the proposed concepts are not available, and "We weren't necessarily trying to identify how many nuts and bolts it took to build a weapon to satisfy preemptive destruction," said Rose. But some concurrent efforts under the ACC's purview may offer clues to what this preemptive SEAD system will look like.

One very viable, if somewhat tangential, product for the new SEAD mission is the Miniature Air-Launched Decoy, a DARPA-owned ACTD awarded to Teledyne Ryan at the end of 1996. An heir to the TALD, which was used in the Gulf War to confuse and saturate Iraqi air-defense networks with false targets, the smaller, inexpensive, but powered MALD will be carried by F-16-sized aircraft and, launched ahead of the aircraft into possible SAM territory, will generate an F-16-sized signature to prompt air-defenses to go live and shoot. Useful for the reactive SEAD mission, these decoys will also serve a preemptive function, since the preemptive concepts assume detection of the threat by an initial emission. Unlike the HARM/reactive mission, however, the preemptive attacker will not require an emitting target in order to follow through with the kill.

For an accurate targeting system that can pick up this emission and then direct a GPS-guided bomb, the Navy-led Joint Emitter Targeting System (JETS) seems to hold promise, although the effort is still in the cost-and-operational-analysis stage and, until it shows more maturity, is not likely to see any commitment of ACC money. Currently, the program management, the Navy's PMA-272, is taking industry input for a JETS, which is intended to provide F-18 and F-16 aircraft with precision direction-finding situational awareness. One recent submission came from McDonnell Douglas, which provided the data from the F-15 Precision Direction Finding (PDF) program once slated to be the successor to the F-4G. Although more capable than the existing HTS, the PDF proved to be too expensive for the Air Force's tight EW budget and was cancelled. This past summer, McDonnell Douglas and teammates TRW/Litton wrapped up demonstration and validation, the last funded leg of the program. According to McDonnell Douglas's Leif Dunn, the PDF, which is based on the Litton/TRW LR-500 receiver/processor and McDonnell Douglas's conformal planar-array antennas, was "incredibly successful.....[It] performed as well as in every case and in many cases better than the F-4G." Whether JETS will spring for such robustness is unknown, however, because the program is considering at least three levels of capability, "and the one that seem to be getting the most attention basically doesn't do a whole lot more than what we're getting with HARM right now," said an Air Force official.

In terms of weapons solutions for preemptive SEAD, the Lethal SEAD Office is awaiting the test report on a weapon called Light Defender, which Eglin's 40th Test Squadron put through captive-carry flight tests in August-September. A cooperative development between IMI of Israel and McDonnell Douglas, the Light Defender came to Eglin as part of the US's 1995-96 Foreign Comparative Test program. Details on the system are scarce; Major Lundie would say only that it is a precision weapon "that has some interesting characteristics for this [preemptive SEAD] mission area." The Lethal SEAD Office will mesh the Light Defender test data with its own modeling/simulation to produce a summary and recommendation on the system for the ACC. JED understands that the system could satisfy one of the mid-range solutions for a munition with some area-search capabilities; an associated targeting system could be SAR/MTI radar, which the Israeli Air Force is rumored to have investigated in conjunction with the Light Defender.

Another weapons system that has captured the ACC's interest for SEAD applications is the Low Cost Anti-Armor Submunition (LOCAAS), according to Major Lundie. An ACTD, the LOCAAS, in its powered version, "solves for targeting accuracy and timeliness," the fundamental requirements for hunting mobile threats. A "smart" submunition that searches the target area in very fine resolution and has extremely long loiter time, the LOCAAS could fit neatly into the weapons-focused SEAD concept. The ACC is working to secure buy-ins on the LOCAAS ACTD to get the project moving, said Major Lundie.

TRADITIONS

What will the ascendance of this new preemptive mission mean for the traditional defense-suppression areas of reactive SEAD and support jamming? What lies ahead of the EA-6B Prowler after this latest, possibly its last, upgrade (which, with improvements to its core receiver capability, will improve its speed and agility both in jamming and HARM targeting; see related article in this month's "EC Monitor")?

In support jamming, said Tony Grieco, the deputy director for EW in the OSD, the basic question is "What is support jamming going to bring to the warfighter? Do we still need it." As an "EW guy," his impulse is to say yes, "but I think it needs to be looked at." If there is one prediction that can be made with confidence, it is that support jamming will not be the domain of a dedicated manned platform. UAVs may take over much of the mission in dense threat areas, and where manned aircraft do come into play, they will probably perform jamming as only one of several functions. One possible picture of a Prowler follow-on is the conceptual F-18 C2 Variant promulgated by a McDonnell Douglas/Northrop Grumman industry team (see the December 1996 "EC Monitor," p. 30). In simulations conducted last fall, the "fast-moving" Variant accompanied a strike package of attack F-18s against a heavily defended nuclear facility. Using novel wingtip receiving pods and lightweight, ram-air turbine jamming pods, the aircraft performed the traditional Prowler functions of soft-kill jamming and HARM suppression, but also demonstrated some new twists for an EW platform: in some cases, it engaged enemy fighters, demonstrating its preservation of the F-18's air-to-air capability. Next year, a

manned simulation will explore the Variant's air-to-ground utility for preemptive destruction, incorporating stand-off weapons like the JSOW, SLAM-ER or Walleye. The scenario, according to McDonnell Douglas's Paul Summers, is that the on-board receiver detects, classifies and locates the emitter, but the emitter shuts down, taking away a HARM response. Using the EW data as a cue, the pilot switches attention to the radar's high-resolution SAR mode, finds the target and launches the stand-off weapon.

Of course, the Variant will remain a virtual capability until the Navy comes up with some seed money to begin an actual program — a possible POM 00 issue. A more corporeal, nearer-term Navy SEAD event occurred recently over China Lake, where the service demonstrated a pylon-mounted Targeting Avionics System (TAS) that gives the F/A-18 "range-known" HARM targeting ability (see related story in this month's "EC Monitor").

The TAS has raised some eyebrows in Air Force circles, however, since the system appears to resemble the HTS closely in form and function.

In the Air Force, the F-16 HTS continues to hone its skills as the Weasel of the foreseeable future. With the decisive damage inflicted by preemptive destruction assets, the F-16 HTS may only need to play a mop-up role for the surviving emitters that dare to come back on line. And what the HTS lacks in capability, the F-16 fleet can make up for in sheer numbers. If necessary, the Air Force can configure an entire swarm of F-16s to "beat down" enemy air defenses in the opening rounds of a campaign, shuttling them back into traditional attack roles as the threat is attrited. So goes the mantra of multifunctionality.

WORST CASE

The SEAD community within the Air Force has obviously thought out its strategy for the future. It remains to be seen whether the Air Force at large will now pay attention. "I kind of have the feeling that the Air Force is gonna sell the farm to keep the tractor. The powers that be want the F-22 and they're gonna do whatever it takes to keep the F-22," said one Air Force official, reflecting the general sentiments of the EW community. According to Major Lundie, the preemptive-destruction study produced some good bottom lines in terms of worst-case scenarios: how much time the shooter has to target an emitter after detection, how much stand-off range and accuracy is needed to ensure survival. The ACC must now decide how far short of worst case it can stop to produce an affordable but viable solution. "Between JETS and Leo's effort [the preemptive-destruction study], we've probably found the extremes and now we, the ACC, need to roll in and start refining some of our assumptions. We know the worst case, but now let's throw a little operator insight into it," said Major Lundie.

Let's just hope that whatever preemptive-destruction solution emerges can live up to its name.

F-16CG/DG

Block 40/42



Night Falcon rollout, aka the first F-16C Block 40. Note the Lantirn pods on the chin stations. (LMTAS Photograph)

The next major production block (Block 40/42), sometimes known as the "Night Falcon" because of its enhanced night/all-weather capabilities, appeared in 1989. It was designated F-16CG/DG when the USAF wanted to call the LANTIRN capable Viper an F-16G, but Congress wouldn't approve a "new" aircraft, which was politically seen as a threat to the F-22.

Block 40/42 (also part of MSIP III) introduced the LANTIRN navigation and targeting pods and the associated holographic HUD, the GPS (Global Positioning System) navigation receiver, APG-68V(5) radar (with a 100+ hour Mean Time Between Failures or MTBF) and ALE-47 decoy launchers, digital flight controls (replacing the old analog ones), automatic terrain following, and a diffractive optics heads-up display. Also included were a new positive-pressure breathing system to improve G-tolerance for the pilot, full provisions for internal electronic countermeasures, an enhanced envelope gun sight, and a capability for bombing moving ground targets.

The configured engine bay has options for either the General Electric F110-GE-100 (Block 40) or the Pratt & Whitney F100-PW-220 (Block 42), although the two engines are not routinely interchangeable. The airframe was provided with greater structural strength, which raised the 9G capability from 26,900 pounds to 28,500 pounds. Maximum take-off weight was increased to 42,300lbs (19,187kg).

The undercarriage legs were made longer in order to provide more adequate clearance for the two underfuselage LANTIRN pods, and were beefed up to handle the increased weight. The aircraft also has bulged landing gear doors to accommodate the larger wheels and tires, and the landing lights were moved to the nose gear doors.

The Martin-Marietta LANTIRN (Low-Altitude Navigation and Targeting Infra-Red for Night) system consists of two separate pods, each mounted underneath the air intake. The AAQ-13 navigation pod is on the left, the AAQ-14 targeting pod is on the right. The navigation pod has terrain-following radar and FLIR, whereas the targeting pod has FLIR and a laser designator. The LANTIRN must interface with the flight controls, since the

pod flies the airplane while in terrain-following mode. The F-16C/D Block 40/42 aircraft were initially fitted with only the navigation pod, since the targeting pod was delayed by technical difficulties.

Provisions for the Texas Instruments (now part of Raytheon) AGM-88 HARM II were added in 1989. The precision weapons incorporated by the Block 40/42 include the GBU-10, GBU-12, GBU-24 Paveway family of laser-guided bombs as well as the GBU-15 glide bomb. Some foreign versions of the aircraft can carry the AIM-7 Sparrow missile.

The first Block 40/42 F-16 rolled out of the Fort Worth facility in December 1988, and was delivered during the same month. Production ended temporarily in 1995, and will restart again in 1999 to build a 21-aircraft order for [Egypt](#). Excluding a potential order from [Bahrein](#), a total of 765 Block 40/42 aircraft will have been built by the end of the millenium.

In 1995, 38 F-16C/D Block 40 aircraft of USAFE's 31st Fighter Wing based at Aviano AB, Italy, were equiped with **Sure Strike**. This package consists of Night Vision Goggles (NVG) and an Impoved Data Modem (IDM), giving the aircraft quick reaction capability for CAS missions over Bosnia. The IDM (now standard on the Block 50/52 and MLU aircraft) allows the aircraft to receive latitude, longitude and elevation of a target direct from a FAC (Forward Air Controller) on the ground. The system then inputs the data into the weapon system computer and displays it as a waypoint on the HUD. Made up entirely from off-the shelf components, it took just 13 weeks to field Sure Strike. The success of the program led to the USAF ordering that Sure Strike software is to be included in conjunction with a rapid release software update recently requested by USAF to improve the weapon-to-aircraft interface of the AIM-120 Advanced Medium Range Air-to-Air Missile (AMRAAM). This action ensures that Sure Strike capability will be included in the major software upgrade (Block 40 tape five) for the close air support update planned in June 1998.

In July 1997, Lockheed Martin was awarded a contract to upgrade the Sure Strike system under a project called **Gold Strike**. Gold Strike basically adds two-way imagery transmission to Sure Strike, enabling the pilot to receive and transmit video images in the cockpit. Software changes will be made within the core avionics computers to display the video images on the F-16's Multi-Function Display (MFD) and to transmit images from the LANTIRN targeting pod. Upon successful completion of the demonstration, the USAF has the option to incorporate this capability in the Sure Strike-modified Block 40 F-16s at Aviano Air Base in Italy.

F-16CJ/DJ

Block 50/52/50D/52D/50 Plus



91-0360, one of the first F-16C Block 50's to be built (LMTAS Photograph)

The Block 50/52 is the current production version of the F-16 Fighting Falcon. It features the Improved Performance Engines, either the F110-GE-129 for the Block 50 or the F100-PW-229 for the Block 52. The F100-PW-229 is lighter and more powerful than earlier F100s, and had been flying at Edwards AFB since mid-1990 in test ship 81-0816. Both engines are rated at 29,000lbs of thrust (129kN). Standard avionics fit includes the Honeywell H-423 Ring Laser Gyro Inertial Navigation System (RLG INS) for rapid in-flight alignment, a GPS receiver, a larger capacity (128KB) Data Transfer Cartridge to accommodate the planned avionics growth, the Improved Data Modem for faster data transmission, the AN/ALR-56M advanced RWR, the AN/ALE-47 threat adaptive countermeasure system, a digital terrain system data transfer cartridge, a cockpit compatible with night vision systems, an advanced IFF interrogator, an Upgraded Programmable Display Generator (UPDG), a MIL-STD-1760 data bus for programming new-generation PGMs, and a horizontal situation display (HSD) for increased situational awareness and tactical flexibility on all missions. The Block 50/52 also carries the Westinghouse AN/APG-68 V(5) radar, which offers longer-range detection against air targets and higher reliability. The radar has a programmable signal processor that employs very high-speed integrated circuit (VHSIC) technology. The VHF/FM antenna is now incorporated into the leading edge of the vertical fin and has an extended operating distance. The cockpit also includes 2 monochrome MFD's (soon to be replaced by the MLU's color displays) and a 25° FOV HUD.

The Block 50s have the possibility to fire the AIM-120 AMRAAM, the new AGM-65G Maverick missile and the PGU-28/B 20mm cannon round. The Block 50/52 is capable of carrying the new JDAM munition, the AGM-145A/B JSOW and is the first F-16 version to integrate the AGM-84 Harpoon antishipping missile. The AGM-137 TSSAM standoff attack missile was cancelled. The aircraft can launch the Harpoon in line-of-sight, bearing-only, and range/bearing modes. The addition of the Harpoon gives the F-16 a significant standoff range anti-shipping capability, especially when combined with optional 600-gallon fuel tanks.

The first Block 50 F-16 was delivered to the USAF in November of 1991. Over 300 have been delivered by early 1997, to four different customers. New production Block 50/52 aircraft ordered after 1996 will also include selected features from the MLU program: color multifunction displays, a three-channel video tape recorder, and the modular mission computer.

Wild Weasel

The F-16CJ/DJ Block 50D/52D have the HARM avionics/Launcher Interface Computer (ALIC) resulting in a full autonomous employment capability of the HARM missile. This capability adds the SEAD (Suppression of Enemy Air Defenses) mission to the already extensive list of missions the F-16 is capable to perform. The aircraft feature full integration for the advanced AGM-88 HARM II and Shrike anti-radiation missiles, a Lockheed Martin Pave Penny laser ranger pod and the Texas Instruments (now Raytheon) AN/ASQ-213 HTS (HARM Targeting System). The pod is mounted on the starboard intake hardpoint and contains a super-sensitive receiver that detects, classifies, and ranges threats and passes the information to the HARM and to the cockpit displays. With the targeting system, the F-16CJ/DJ has full autonomous HARM capability. The HTS pod can be omitted however - in that case, RC-135 Rivet Joint aircraft support the F-16 in sorting and prioritizing targets in dense threat environments. Two HARM missiles are normally carried on a typical SEAD mission, however, 4-missiles loads are currently being test-flown at Eglin AFB.

Deliveries of the Block 50D/52D began in May 1993. All but the earliest Block 50 models have been upgraded to Block 50D standard.

Block 50 Plus / Block 55 Glass Falcon

The Block 50 Plus is a projected version which has special provisions for the adverse weather delivery of the McDonnell Douglas JDAM (Joint Direct Attack Munition). The update would include an add-on tail unit containing synthetic aperture radar, providing guidance to 1,000lbs Mk.83, 2,000lbs Mk.84 and the 2,000lbs BLU-109 warhead. Other features include passive missile warning, terrain-referenced navigation, and provisions for the 600 US gal (2,271 litre) external fuel tanks. The new F-16 will be basically the same with some minor adjustments to the internal structure and a completely redesigned cockpit. The third generation cockpit will have all analog instrumentation replaced by digital equipment. The radar warning receiver scope will be deleted and will be incorporated in the new multi-function displays (MFD) which are twice as large. This new F-16 is nicknamed the "Glass Falcon" among the employees at Lockheed. The powerplant is planned to be a Pratt and Whitney F-100-229A, which is rated at 35,000 pounds of thrust in full augmented mode.

Three-Four-Nine: <http://allserv.rug.ac.be/~svhastel/index.htm#f16>



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55th Fighter Squadron Fact Sheet / 78th Fighter Squadron Fact Sheet / 79th Fighter Squadron Fact Sheet

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F-15E Strike Eagle

With the recent retirement of the FB-111, the F-15E has become the USAF's premier deep strike/interdiction aircraft. The original F-15 design has come a long way from its role as an interceptor. While externally it may look similar to a mere two-seat Eagle, the F-15E is very much its own aircraft.

Born out of a desire to replace the F-111, the Air Force looked towards a private venture created by McDonnell Douglas to create a strike version of their air superiority fighter. The idea was to create a fighter-bomber which could conduct its strike mission with a minimum of support and without the need for accompaniment by escort fighters. While the original prototype, dubbed the "Strike Eagle" was a modified F-15B, today's F-15E is a different aircraft both inside and out. While still retaining its air-superiority characteristics, the F-15E can carry aloft a heavier payload than its predecessors and deliver it greater distances. It is quite a change from the "not a pound for air-to-ground" motto that heralded the Eagle's introduction.

The F-15E was the unsung hero of Desert Storm. The aircraft logged approximately 7,700 combat hours in the air during the conflict, with each of the two squadrons present in the theatre flying some 1,200 missions. F-15Es were among the first aircraft to lead the strike against Iraq during the opening night of the war, and appeared over the skies of Baghdad. From that initial attack, they struck at strategic targets such as communication facilities, key bridges, and command & control facilities deep in the heart of Iraq. F-15Es were key players at night in the hunt for SCUD missiles in the desert near the Jordanian border as they worked closely with E-8 JSTARS aircraft who searched the desert-floor for launchers and storage units. Due to the F-15E's precision-strike capability, it could carry the fight to the enemy both day and night.

In addition to these types of sorties, F-15Es also took part in tactical strikes against tanks in the Kuwaiti Theatre of Operations. Armed with laser-guided GBU-10s, F-15Es routinely assisted A-10s in missions dubbed "tank-plinking." Again, the F-15E was able to carry out such operations 24 hours a day. Throughout the entire campaign, the F-15E's displayed stellar performance. However, the true "bomb trucks" of the USAF were the F-111s and the F-15Es.

Specifications:

Builder: McDonnell Douglas

Role: Strike/Interdiction

Length: 63' 9"

Wingspan: 42' 9.75"

Height: 18' 5.5"

Wing Area: 608 sq. ft.

Weight Empty: 31 700 lbs

Max T-O: 81 000 lbs

Payload: 24 500 lbs

Engines: F100-PW-229

Number: 2 afterburning turbofans

S.T. Dry: 17 800 lbs

S.T. A-B: 29 100 lbs

Max Speed @ 35K: 1 500 mph

Fuel – Internal: 2 019 US gal (7 643 litres)

Total CFTs: 1 446 US gal (5 474 litres)

Total + Tanks: 5 295 US gal (20 044 litres)

Combat Radius: 790 miles

Ferry Range: 2 765 miles

Radar: AN/APG-70

HUD: Kaiser IR-2394/A

Fixed Weapon: M61A1 20mm Cannon

Crew: 2 (Pilot & Weapons Systems Officer)

Airframe

While essentially retaining the same dimensions of a two-seat Eagle, the F-15E's structure has been redesigned and strengthened, allowing an increase in takeoff weight from 68,000 to 81,000 pounds. Approximately 60% of the aircraft saw this redesign which has created a fatigue life of 16,000 hours and has allowed up to 9g of maneuvering. Due to the redesign, the bring-back capability of the aircraft has been increased as well, reflected in a maximum landing weight of 44,300 pounds.

A variable camber wing was rejected during the design due to weight and complexity concerns. As a result, the wing is of fixed leading edge with conical camber. This results in only a marginal drag penalty at supersonic speeds and slightly reduced subsonic performance. Wingtips have been modified from their original shape, with 3 sq. ft. clipped from each to eliminate severe buffeting present both at high g loads and at high subsonic speeds at altitudes in excess of 30,000 feet.

Wing Specifications

Wing Area	608 sq. ft.
Wing Sweep	45 deg.
Aspect Ratio	3
Incidence	0 deg.
Anhedral	1 deg.
Max. Loading	133.2 lb./sq. ft.

The twin vertical fins found on all F-15s allow for greater directional stability at high angles of attack by using the vortex flow that emerges from the wing. Further aiding in the aircraft's performance at high angles of attack are a pair of variable geometry engine intakes located on either side of the fuselage, providing a straight path to the engines. These variable intakes are capable of adjusting their angle in order to provide an adequate airflow to the engines at various speeds and at high angles of attack. Controlled by an air data computer, and manipulated hydraulically with the fulcrum at the bottom edge, the intakes are capable of angles varying between 11 degrees below the aircraft's horizontal and 4 degrees above. Within the intakes themselves, mechanically controlled ramps are present to suppress shockwaves that may result due to air entering the inlets at speeds at or above Mach 2.

Flight Controls

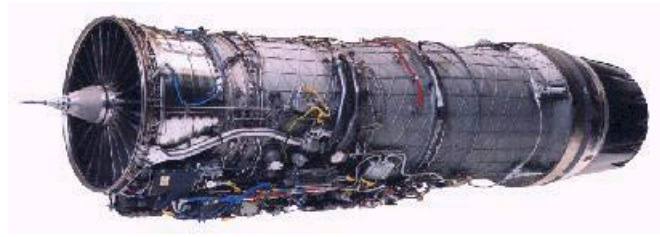
Flight control provided by a Lear Astronics digital system. Triply-redundant with a mechanical back-up, the system can be coupled to the terrain-following radar for full hands-off flight. Tailplanes are all-moving with notched dog-tooth leading-edges to prevent flutter. Plain ailerons and flaps. Rudders make use of no spoilers or trim tabs. Control surfaces powered by hydraulic actuators. Speedbrake is located on the upper-fuselage just aft of the cockpit and opens upward, hinged forward of the surface. Flight column features a boost and pitch compensator.

Conformal Fuel Tanks (CFTs)

Giving the F-15E a beefier appearance are two Conformal Fuel Tanks (CFTs) which attach to either side of the fuselage, serving a dual role. Each CFT is capable of carrying 723 US gallons of fuel with less drag than would be present using standard external tanks. Each CFT also features six stub-pylons for the mounting of ordnance. The stubs are placed tangentially, causing less drag than would be present with the use of the standard Multiple Ejection Racks mounted to the wing stations. Their placement arranges the bombs in two rows along the sides of the aircraft. This reduced drag translates into slightly higher speeds and increased range.

Powerplant: F100-PW-229

Since 1991, the Dash 229 version of the Pratt & Whitney F100 series has powered the F-15E starting with the 135th production aircraft (90-0233). Prior to that time, power was supplied by the Dash 220. The PW-229 provides a 24% increase in thrust through increased airflow and fan pressure ratio. This translates into 17,800 pounds dry thrust and 29,100 pounds of thrust at full augmentation. One of the most distinctive features of the PW-229 is the bluish tinge that colours its afterburner plume. The updated DECU (Digital Engine Control Unit) allows the Dash 229 to spool up from idle to full augmentation in under four seconds, approximately half the time required by the Dash 220. The compression ratio for the PW-229 is 0.36:1 while the overall pressure ratio is on the order of 32:1. With a weight of 3,740 pounds the Dash 229 delivers a thrust-to-weight ratio of 8:1 at full augmentation. The F100 series of engines has flown since July 1972 in the prototype F-15 and has assisted the F-15 in achieving a number of time-to-climb records during the 1970s. A low-bypass turbofan, the P&W F100 series features a 3-stage fan, a 10-stage compressor, a 2-stage compressor-drive turbine, and a 2-stage fan-drive turbine. The F100 series also features an augmentor for afterburning.

**F100-PW-229**

Thrust (Dry)	17,800 pounds
Thrust (A-B)	29,100 pounds
Weight	3,740 pounds
Length	191.0 inches
Inlet Diameter	34.8 inches
Maximum diameter	46.5 inches
Bypass ratio	0.36:1
Overall pressure ratio	32:1

Engine accessories such as drive shafts supplying power to the aircraft systems, are mounted to the airframe rather than the engine. As a result, any engine can be mounted in either the port or starboard engine bays. This provides greater ease to maintenance crews while at the same time eliminating what could be a logistical nightmare during times of war. Engines are removed by sliding them out the rear of the aircraft on rails built into the airframe. Each engine needs disconnection from only ten attachment points before it may be removed. From that point, it is slid out onto an elevated trolley

for transport or immediate maintenance. The engines are separated by titanium walls to minimise the possibility of damage to both engines when one is hit. Between the two barriers, there is a pressurised extinguisher bottle which can release fire-suppressing foam into either engine bay or into the void between the firewalls. Power for engine start is provided by an APU (Auxiliary Power Unit) manufactured by AlliedSignal. This unit also generates limited electrical and hydraulic power on the ground when the powerplant is not operating.

Aircraft Systems

Since 1991, oxygen has been provided by a molecular sieve oxygen generating system (MSOGS) manufactured by Litton Industries. This replaced the older liquid oxygen system that was standard in the F-15E. Hydraulic power provided by three independent hydraulic systems rated at 3,000 lbs/sq. in. powered by engine-driven pumps. Electrical power provided by a Lucas Aerospace generating system featuring constant-speed drive units rated at 60/75/90 kVA.

Hydraulics for the F-15E are supplied by three separate systems, isolated from each other so that battle-damage will be less likely to cause a system-wide failure. The hydraulic system is capable of isolating leaks and routing the path around the breaches.

Undercarriage

Tricycle landing gear features a single wheel on each hydraulically forward-retracting unit. Single oleopneumatic shock absorbers and Michelin AIR X radial tire at each point of the carriage system. Braking for all wheels provided by a Bendix five-rotor carbon disc brake.

APG-70 Radar

The APG-70 is based on the F-15C's APG-63 pulse-doppler radar which was optimised for the detection of air targets. The APG-70 retains all of the excellent capabilities of the APG-63 while at the same time featuring additional functions to aid in the precision strike role. The most notable feature of the APG-70 is its ability to produce photo-realistic patch maps of a given area down to the 8.5 foot (2.6 m) resolution. This resolution however can only be attained while within 10 nautical miles of the target. At greater distances the resolution diminishes to a maximum of 127 feet (38.7 m) at 160 nautical miles from the target. The quality of the HRM is also dependent on the "grazing angle" of the radar, the angle at which the radar beam strikes the surface that is to be mapped. The APG-70 has a minimum angle of 0.5 degrees which translates into an altitude of 1,000 feet for every 20 nm from the target. As a result, if the F-15E is performing a low-level ingress, the aircraft must increase altitude temporarily while the radar generates a HRM.

LANTIRN

The LANTIRN (Low-Altitude Navigation and Targeting Infra-Red for Night) system is made up of two separate pods, one mounted under each air-intake of the F-15E.

One pod is primarily for low-level navigation in poor weather conditions while the other pod performs targeting roles. The AAQ-13 navigation pod under the right intake features a Texas Instruments terrain following radar which operates in the Ku band. Mounted inside the lower cylindrical pod of this two-level package, the antenna for this radar is located behind a small radome at the front of the unit. This radar has been coupled with the flight controls and throttle to provide a hands-off terrain-following course while maintaining a constant altitude down to a minimum of 200 feet. Mounted above the TFR pod is the Forward Looking Infra-Red (FLIR). Through a small window at the front of the unit, the FLIR provides the pilot with a 1:1 IR image of the world which is superimposed on the aircraft's Head Up Display (HUD), allowing the pilot see at night. Beneath the left intake, the AAQ-14 targeting pod is made up of a separate attack FLIR and laser designator/range-finder housed inside of a small aerodynamic turret at the front of the cylindrical pod. The FLIR can be slaved to the radar or controlled separately by the crew in order to provide a view of the designated target. This FLIR offers several levels of magnification to allow for identification of targets from considerable distance. The laser designator/range-finder is correlated with the attack FLIR and can provide accurate ranges to designated objects. In addition, it is capable of sending specially-coded bursts of laser for the guidance of laser-guided bombs. The turret moves in relation to the target so that alignment of the sensor is independent of the aircraft's motion.

AN/AAQ-13 Navigation Pod		AN/AAQ-14 Targeting Pod	
Length	78.2 inches (1.99 meters)	Length	98.5 inches (2.51 meters)
Diameter	12 inches (0.31 meters)	Diameter	15 inches (0.38 meters)
Weight	470 pounds (211.5 kilograms)	Weight	524 pounds (235.8 kilograms)
Unit Cost	\$1.38 million	Unit Cost	\$3.2 million

Cockpit

Controlling this avionics package is a crew of two who occupy a cockpit optimised for the strike role and designed to ensure an efficient division of labour. The pilot is seated in the front while the Weapons System Operator (WSO) is seated directly behind the pilot under a single canopy. Both cockpits feature flight controls though the WSO is typically not a qualified pilot. The pilot's station features a Kaiser ID2349/A wide-angled HUD below which is mounted the Up-Front Controller which is used to select radio channels and to enter in navigational data. Mounted on either side of the UFC are a pair of 6"x6" Kaiser monochromatic Multi-Function Displays. Below the UFC is mounted a 5"x5" Sperry colour Multi-Function Display. Each of these three MFDs can display a wide variety of data as well as radar and FLIR images. Superimposed on these displays are menu options that can be selected using either via buttons mounted to the bezel of each MFD, or through the HOTAS controls mounted on the stick and throttle.

The WSO station features a row of four MFDs with two Sperrys at the ends of the row, and two Kaisers occupying the two inner positions. In addition to the normal flight controls, the WSO has a separate hand-controller on each side of the seat in order to more efficiently control the sensors and the displays. Like the stick and throttle, these two controllers are studded with switches and buttons so that the WSO does not have to look away from the displays to search for a particular control. The WSO station also has its own UFC, but it is mounted off to the side under the right MFD.

Defences

To survive in the skies above the modern battlefield, the F-15E is outfitted with an electronic warning/defence package designed to detect threats, classify them, and provide adequate protection against those threats. The heart of this defensive system is known as the Tactical Electronic Warning System (TEWS). The TEWS alerts the pilot to threats to the aircraft and administers countermeasures against those threats. The Radar Warning Receiver is made up of spiral antennas located in the wingtips and in small fairings at the ends of the left vertical stabiliser. There is also a blade antenna located forward of the nosewheel bay. Upon detection, the system then decides on the best countermeasure mix to use in order to counter the threat radar. Electronic countermeasures are delivered via the ALQ-135C radar jammer through antennas located at the tip of the right vertical stabiliser and in fairings at the end of each tail-boom. Countermeasures can also be delivered by way of the Tracor ALE-45 chaff/flare dispensers.

Designed Flexibility

The business of the fighter-bomber is weapons delivery, and the F-15E is equally as capable in both the air-to-air and air-to-ground roles. This provides enormous flexibility to military planners who must take into account the unpredictable nature of warfare. While the primary role of the F-15E is as a strike aircraft, it could theoretically be used to defend an airspace as well. The ability to carry a mixed load of air-to-air and air-to-surface weapons also means that the aircraft has the capacity to defend itself while performing the strike role. The F-15E is capable of fielding nearly every weapon system in the USAF's inventory, including a wide range of precision-strike ordnance. In addition to the sheer variety of weapons that the F-15E is capable of delivering, the design features of the aircraft allow it to carry aloft an impressive amount of ordnance. The F-15E owes this to both the structural enhancements to its airframe, and the Conformal Fuel Tanks that grace its lines.

Conformal Fuel Tanks

One of the features that makes the F-15E a most impressive fighter-bomber is the pair of Conformal Fuel Tanks (CFTs) that run along either side of the fuselage. In addition to providing a considerable fuel supply to the aircraft without the extensive drag penalty of external tanks, the CFTs provide additional hardpoints from which ordnance can be mounted. Mounting ordnance to the CFTs reduce drag forces typically imposed by the Multiple Ejector Racks (MERs) common to other military aircraft. MERs

cluster bombs close beside each other in the airstream, resulting in each bomb interfering with the accelerated airflow around each of the other bombs. This causes increased levels of interference drag between the bombs on each MER. This in turn affects both aircraft performance as well as bombing accuracy as these drag forces create excessive pitching and yawing motions on the bombs upon initial release. The F-15E's CFTs mount ordnance conformally in order to reduce drag. Conformal carriage refers to positioning the hardpoints so that ordnance follows the contour of the structure that they are being mounted to. In the case of the F-15E, bombs are laid along each CFT in two rows. In each row, the forward hardpoint positions the bomb slightly nose-up, the centre hardpoint mounts the bomb level to the aircraft, while the aft hardpoint positions the bomb slightly nose-down. This results in a cleaner airflow around the bombs which in turn, reduces the interference drag common among MERs. As a result, airflow around the aircraft is cleaner as well. This translates into increased performance, speed, and range for the aircraft as compared to a similar bomb load utilising MERs.

Each CFT features a lower row made up of a continuous ordnance pylon running fore-to-aft, and an upper row made up of three stub pylons. The lower row can be configured in order to mount two air-to-air missiles, three small bombs such as the Mk-82, two large bombs such as the Mk-84, or two bombs with guidance-packages. The upper row typically features one small bomb per pylon for a total of three bombs, or a total of two small bombs equipped with guidance-packages. No air-to-air missiles can be mounted along this upper row.

Additional Hardpoints

In addition to the CFTs, the F-15E features three additional hardpoints, one on each wing and a single hardpoint along the aircraft centreline. These hardpoints are "wet", each capable of accommodating a 600 US gal. fuel tank which can be discarded. MERs can be mounted on these hardpoints in order to increase the warload of the F-15E if necessary. Extremely heavy ordnance or air-to-surface missiles are mounted on the wing-stations due to the strength and clearance of this hardpoint.

Air-to-Air Weapons

Each CFT has the capacity for carrying a pair of air-to-air missiles on its lower rack, either AIM-7 Sparrows or AIM-120 AMRAAMs. From these stations, missiles are "cold-launched", a process that involves ejecting the missile down and away from the CFT before its rocket motor engages. For the sake of flexibility, air-to-air missiles can be mounted on one CFT while air-to-ground ordnance is mounted on the other. This option was seen occasionally during the Gulf War.

Mounted along either side of the wing pylons are LAU-114 launch rails for AIM-9 Sidewinders, AIM-120 AMRAAMs, or any combination of the two. This allows the F-15E to field at least four air-to-air missiles, even while the CFTs are carrying air-to-ground ordnance. This has obvious self-protection benefits for the aircraft while performing the strike role.

M61A1 Vulcan Cannon

As with all F-15s, the fixed weapon of the F-15E is the 20mm General Electric M61A1 Vulcan cannon. This weapon features six rotating barrels which allows for a firing-rate of approximately 6 000 rounds per minute, while at the same time reducing erosion of the barrels, resulting in extended service-life. The rotary action for the F-15's M61A1 is supplied by hydraulic/electrical power.

The barrels and drive mechanism of the cannon are located in the starboard wing root of the F-15E while the 512-round ammunition drum is located along the aircraft's centreline between the forward and centre-fuselage fuel tanks. The F-15E's ammunition drum carries a total of 512 rounds as compared to the A through D models of the F-15 which carry a maximum of 940 rounds. A linkless feed chute runs between gun and ammunition drum, supplying the cannon with the ammunition and transporting the spent casings back to the drum. The M61A1 uses the M50 series of 20mm ammunition.



B-2 - Revolutionary Military Capability

The U.S. Air Force's B-2 is the only aircraft in existence to combine long range, large payload, low-cost precision weapons and stealth technology in one platform.

U.S. based B-2s can strike virtually any point in the world within hours, in adverse weather conditions, carrying effective, powerful precision weapons. The B-2 Spirit can hedge against a surprise attack abroad and allow the U.S. military to project decisive military power when foreign bases are unsecured or unavailable.

Crew: Two: Pilot and Mission Commander

Wingspan: 172 feet

Length: 69 feet

Height: 17 feet

Gross Weight: More than 350,000 lb

Payload: More than 40,000 lb

Unrefueled Range: More than 6,000 nautical miles

Range with One Refueling: More than 10,000 nautical miles

Power Plant: Four F118-GE-100 Turbofan

Thrust: 19,000 lb class

Speed: High subsonic

Ceiling 50,000 feet

According to the U.S. Air Force, the primary mission of the B-2 is "to enable any theater commander to hold at risk and - if necessary - attack an enemy's war making potential, especially those time-critical targets which, if not destroyed in the first hours or days of a conflict, would allow unacceptable damage to be inflicted on the friendly side. The ability of the B-2 to perform these tasks in the face of modern air defenses reduces both the likelihood and probability of success of regional aggression."

From its inception, the B-2 was designed to fully incorporate all aspects of stealth technology. This includes minimization of radar emission or "signature" and of all other observable phenomena, including the aircraft's visual, infrared (heat), acoustic (sound), and electromagnetic (e.g., radio) signatures. The current program calls for the delivery of 21 fully operational B-2 bombers to the Air Force's 509th Bomb Wing at Whiteman Air Force Base, Missouri. The first B-2 was delivered to the 509th on December 17, 1993 and was named "The Spirit of Missouri." Each of the B-2 Spirit Bombers is named for various states.



Introduction

This section will briefly cover specifics of the F-22 Raptor air dominance fighter itself and how the Air Force/contractor team intends to test it.

The demonstration and validation (dem/val) phase began in 1986 and was completed in 1990 with 74 flights on the two prototype YF-22s. After the then-Lockheed Boeing General Dynamics airframe team and engine supplier Pratt & Whitney were selected in April 1991 and the contract award in August 1991, another 39 flights were subsequently flown on the Pratt & Whitney powered YF-22 prototype in a follow on dem/val effort. The program is just over midway through the Engineering and Manufacturing Development (EMD) phase, with first flight of the first of nine F-22As to be built in EMD scheduled to be flown in May 1997. Two additional airframes for ground based static and fatigue testing will also be built.

Subsequently, the production phase will begin with a total of 438 F-22s scheduled to be built between 1998 and 2013. The F-22 is on schedule to reach Initial Operational Capability (IOC) with 32 aircraft in 2004.

The General Challenge

The F-22 will be in service for more than 25 years, or more than 40 years from the time of what was then called the Advanced Tactical Fighter dem/val contract was awarded in 1986.

Projecting that far into the future is difficult and one can get an idea of the magnitude of the challenge by comparing the best U. S. air dominance fighter of 1940, the P-51, with the F-4 25 years later. In that time, speeds had quadrupled and weapons and sensors were unlike anything available to the World War II pilot.

Perhaps most importantly, this 25 year leap occurred with a revolution in fighter aircraft—the conversion from propellers to jet power. These relatively rare revolutions are marked not by incremental improvements, but rather, profound new directions in design. All of the aircraft from this revolution on will follow the new branch or will be hopelessly outclassed.

It would have been ludicrous in 1945 to argue that the P-51 was the only fighter the U. S. would need for the next 25 years, but in 1945 few people could imagine just how far the science of flight would progress, or the impact of the switch from props to jets. Yet the aircraft designer of today is being asked to make a similar leap.

The F-22 Approach

Rather than a brute force approach with better thrust to weight engines, lower wing loading, sustained or instantaneous turn performance, maximum speed, maximum altitude, or post stall, high angle of attack (AOA) maneuvering; and faced with the realities of

reduced defense budgets and fewer fighters in the future, the F-22 team established three basic guidelines for a fighter slated for operations in an uncertain future:

Exploit Information

Deny Information to the Enemy

Overwhelming Lethality

The F-22 is designed to exploit information, that is, to gather information from many sources and then process that information into a simple, intuitive picture of the tactical situation for the pilot.

The F-22's airframe and avionics architecture is specifically designed to provide these capabilities without locking the design into any particular use of equipment or capabilities available in 1997.

The F-22 is also designed to deny the enemy information on where the F-22 is and what it is doing.

If fewer numbers of fighters are to be built, then they must be overwhelmingly lethal compared to the aircraft of today. This level of dominance was hinted at during Operation Desert Storm where fewer aircraft, using precision munitions, accomplished greater destruction of military targets in a shorter period than in previous American wars.

If a similar level of lethality can be attained in an air dominance fighter, then fewer aircraft will have a far greater impact in the air battle.

In short, in a future air battle, with American lives at risk, there is no interest in that battle being a fair fight. The U. S. must win quickly, decisively, and with minimal casualties.

The Key: An Exponential Increase in Computer Power

To design an airplane that embodies these characteristics means moving beyond traditional design approaches. The common thread to making the 25 year leap, answering the government's challenge of making the F-22 twice as effective as the F-15, solving the technical and organizational challenges of running the program, and implementing the three points of the F-22 design approach lies in the extensive use of computers.

The exponential explosion of computer technology in the last 10 years has allowed the F-22 team to radically alter every aspect of this program from detailed design through manufacturing, communication, and into the cockpit itself.

To put this into perspective, the computer used in the Lunar Module operated at 100,000 operations per second and had 37 kilobytes of memory. Today, the F-22's main mission computers, which are called Common Integrated Processors or CIPs, operate at 10.5 billion instructions per second and have 300 megabytes of memory. These numbers represent 100,000 times the computing speed and 8,000 times the memory of the Apollo moon lander.

Impossible, Maybe, Probable

In 1986, the IBM 286 computer was just coming into service with the general public. The avionics goals for the F-22 seemed huge and the team's confidence in meeting the computational and information management to the pilot was relatively low.

For instance, a fiber optic transmitter and receiver (FOTR), a part of the display avionics, was roughly the size of half a sheet of paper in 1986. By 1990, that same computational power had been shrunk to the approximate size of today's computer disk, and the team's confidence was increasing.

Today, that same computing power has been packaged into a small device a little bigger than a business card, and size, weight and power requirements for these types of modules continue to drop. Confidence is now high that what was planned for is indeed achievable. Such a quantum leap in capability has not been limited to the F-22 aircraft itself.

Computational power has greatly changed the use of computers in all aspects of the F-22 program from design, through manufacturing, and even the testing of the airplane.

CATIA and COMOK

The computer revolution has changed the detail design process of the aircraft. With IBM Dassault Systemes designed Computer Aided, Three Dimensional Interactive Application (CATIA), the aircraft designer can design the parts of the F-22 as a solid object, not just lines on a flat page.

With COMOK (a team developed computer mockup simulation), the designer can visualize every aspect of the design including complex routing for wires, tubes, and cables. There is no hard mockup of the F-22.

These computer programs allow the design engineer and the manufacturing engineer to look inside the structure before it is built.

More than just a visualization, the computer data that creates these images are precisely stored design measurements that can be transferred, again by computers, between the team's locations in Marietta, Ga., Fort Worth Texas, Seattle, Wash., and West Palm Beach Fla., and East Hartford, Conn. and supplier locations all around the country.

Parts of the aircraft fit remarkably well when received in Marietta, where final assembly takes place, even though no master tool was sent to trial-fit the pieces.

The F-22 Design

The design of the F-22 addresses the challenge of air dominance in two ways, one traditional and one non traditional.

The traditional and most obvious approach to dominance is to create highly advanced machinery in the form of an aircraft with (1) better speed, (2) better turning performance, (3) better weapons, or (4) specialized technologies, such as stealth.

The most publicized and most revolutionary technology for aircraft is stealth. Stealth makes an object become very difficult to detect by sensors such as radar, heat seekers (infrared), sound detectors, and even the human eye. While not invisible, the F-22's radar cross section (RCS) is comparable to the radar cross sections of birds and bees. Compared

to other current fighters, the F-22 is much more difficult to detect. (See Stealth section for slightly more detail).

Supercruise and Agility

The traditional design approach stresses increases in aerodynamic performance, and the F-22 emphasizes two technologies. Supercruise is the term given to the capability of sustaining supersonic speeds for long periods of time.

Conventional fighters, while capable of supersonic flight, can only sustain these speeds for relatively short periods as the result of excessively high fuel consumption using afterburner. The F-22 can cruise supersonically without afterburner and, therefore, can sustain these speeds for long periods.

The question could be asked "So what?". The enemy must react to any intruder and that reaction time to detect, aim weapons, and launch, is severely reduced when the intruder is moving fast. At supercruise speeds, the F-22 (and its pilot) becomes less vulnerable to enemy missiles and aircraft simply because they cannot react fast enough.

Agility is the ability of the F-22 pilot to point and shoot with his aircraft, pirouetting, and facing the enemy with his weapons at all speeds. The F-22 pilot can maintain control of the aircraft at speeds as low as that of a Piper Cub or at very high supersonic speeds.

Avionics

Avionics share as large a part in the success of a fighter as the ability to maneuver and fly fast, or to "turn and burn". F-22 avionics reflect the quantum leaps in computer technology in the last 10 years. "Integrated" means that the F-22 can take information from many sources, compare that information and determine a single, consistent picture of the world around the pilot. In addition to these external inputs gathered by the F-22's own sensors, several F-22's can exchange information by means of the aircraft Inter/Intra Flight Data Link (IFDL) and additional information can be gathered from off board sensors like E 3 Airborne Warning and Control System (AWACS) aircraft and satellites.

Integrated avionics have some unusual characteristics. The F-22 has no radios, navigation gear like TACAN or Global Positioning System (GPS) or Instrument landing System (ILS) or even a radar in the traditional sense.

The Common Integrated Processor modules have the ability to emulate any of the electronic functions through automatic reprogramming. For example, if the CIP module that is acting as radio dies, one of the other modules will automatically reload the radio program and take over the radio function. This approach to avionics makes the equipment extremely tolerant to combat damage as well as flexible from a design upgrade point of view.

The aircraft's avionics architecture remains flexible to accept future upgrades without having to design and retrofit new hardware to the fighter.

The Non-Traditional Design Approach

There is also a non-traditional design approach that was used for the F-22. The non traditional approach was driven by the reality of smaller military budgets, fewer aircraft, and a requirement to make those few aircraft far more lethal than their predecessors. In World War II, the U. S. Army Air Corps downed 15,798 aircraft in day air to air combat. Those kills were made by only 7,306 of the approximately 35,000 fighter pilots in combat. Of that number only 1,284 were aces. In other words, only 21% of the fighter pilots shot down other aircraft and only 3.6% were aces. In the Korean War, similar results occurred for the dedicated fighter pilots. There, 4.8% of the pilots were aces but they got 38% of all kills.

The F-22 team reasoned that a smaller force could be far more lethal if the percentage of fighter pilots who achieve combat kills could be increased significantly from the historical averages of 10 to 20%.

"Human Potential" Design Concepts

These engineering concepts were formalized in the F-22 design process by defining three basic design criteria for the pilot:

Eliminate "housekeeping"

"Carefree abandon" flying qualities

Maximize information, minimize data

This elimination of "housekeeping" design criteria was driven by the desire to off load the pilot from the many system operations that have classically taken a significant portion of the pilot's attention in the cockpit.

The question was asked, "Why should an airplane be any more complex to operate than your car?" Is there really a need for "all those little switches, knobs and dials in the cockpit?" Like a car, the basic approach was to make the operation of the F-22 a true "kick the tires and light the fires" machine. All switches, even the most traditional functions, had to earn their way into the cockpit.

It became apparent that computers and Built In Testing (BIT) could replace much of the traditional pilot "housekeeping". Interestingly, the pilots did not drive this capability.

The Crew Chief Got There First

Maintainers were included early in the design process for the F-22, and they quickly established a strong foothold. To improve maintenance turnaround, the maintainers insisted on extensive self diagnostics and BIT capability for the various subsystems. As a result, virtually every piece of hardware in the aircraft either does its own health checks or reports when it has failed. There are more than 15,000 fault reports that can be made on the basic engine and airframe and another 15,000 fault reports available for the avionics. Most of these are low level fault reports that do not result in warnings, cautions, or advisories to the pilot or degrade the operation of the F-22.

It was reasoned that if the airplane knew so much about itself, then that capability could be leveraged to help the maintainer and the pilot.

Tactician not Housekeeper

The idea was to relieve the pilot of the bulk of system manipulations associated with flying and allow him (and now her) to do what a human does best - be a tactician. Using the power of the onboard computers, coupled with the extensive maintenance diagnostics built into the F-22 by the maintainers, that workload has been significantly reduced.

Aircraft startup and taxi are excellent examples of harnessing the power of the computer to eliminate workload. There are only three steps to take the F-22 from cold metal and composites to full up airplane ready for takeoff. The pilot places the battery switch ON, places the auxiliary power unit (APU) switch momentarily to START and then places both throttles in IDLE. That's it.

The engines start sequentially right to left, the APU then shuts down, all subsystems and avionics are brought on line and BIT-checked, the necessary navigation information is loaded and even the pilot's personal preferences for avionics configuration is read and the systems are tailored to those preferences. All of this happens automatically with no pilot actions other than the three steps. The airplane can be ready to taxi in less than 30 seconds after engine start.

To reduce pilot workload in flight, the F-22 incorporates a unique caution and warning system called Integrated Caution, Advisory, and Warning (ICAW) system.

ICAW messages normally appear on the 3"x4" up front display (UFD) just below the glare shield. A total of 12 individual ICAW messages can appear at one time on the UFD and additional ones can appear on sub pages of the display.

Two aspects of the ICAW display differentiate it from a traditional warning light panel. First, all ICAW fault messages are filtered to eliminate extraneous messages and tell the pilot specifically and succinctly what the problem is. For example, when an engine fails, the generator and hydraulic cautions normally associated with an engine being shutdown are suppressed, and the pilot is provided the specific problem in the form of an engine shutdown (ENG SHUTDN) ICAW message.

More than two years of detail design by pilots and engineers has gone into the filtering logic of the ICAW system and an extensive test of the system will occur in the Vehicle System Simulator (VSS) or 'Iron Bird' and the avionics labs. (See VSS and AIL in the Other Testing section).

In addition, the success of the Army's RAH 66 Comanche helicopter's ICAW system that uses a similar filtering approach gives the F-22 team confidence in the fundamental soundness of the design.

Another feature of the ICAW system is the electronic checklist. When an ICAW message occurs, the pilot depresses the checklist push button (called a bezel button) on the bottom of the UFD and the associated checklist appears on the left hand Secondary Multi-Function Display (SMFD).

If multiple ICAWs occur, their associated checklists are selected by moving a pick box over the desired ICAW and depressing the checklist button. Associated checklists are automatically linked together so that if an engine failure occurs, the pilot will not only get

the checklist for the engine failure procedure in-flight but also the single engine landing checklist. The pilot can also manually page through the checklists at any time from the main menu. This is particularly handy when helping a wing man work through an emergency.

"Carefree Abandon" Flying Qualities

The second design principle is really an extension of the philosophy for the cockpit itself. "Carefree abandon" translates into the ability of the fighter pilot to do whatever he wishes with the F-22, without fear of loss of control, loss of thrust, or aircraft structural overstress.

Specifically, this has translated into an unlimited angle of attack (AOA) capability for the aircraft's basic combat configuration (i.e. all internal carriage of weapons and no external stores). There are no AOA limiters, and, most importantly, no restrictions on flightpath. The pilot can run the airplane out of speed and maneuver in the post stall regime with integrated flight controls and thrust vectoring. The F-22 responds smoothly to the pilot and can change flight condition at his command.

Carefree also applies to structural limits on the airplane, and this is handled two ways. First, all the traditional limitations seen in flight manuals have been coded into onboard computers. For example, some components (such as landing gear and air refueling doors) have speed limits. The pilot is never prevented from exceeding those limits.

If the pilot exceeds a limit, either intentionally or unintentionally, he gets an ICAW with an aural warning to tell him that a limit is being exceeded. In addition to overspeed warnings to the pilot, the flight control system provides load limiting for all pilot inputs as a function of aircraft gross weight.

Second, the flight control system provides automatic load limiting for all pilot inputs as a function of aircraft gross weight. The pilot gets the maximum performance the aircraft is capable of achieving at any time when full roll, pitch or yaw commands are used. The pilot can 'yank and bank' all he wants without fear of hurting the airplane.

These flying qualities are backed by more than 8,000 hours of stability and control wind tunnel testing (during the EMD testing phase alone), thoroughly tailored flight control laws, and countless handling quality simulation evaluations - all of which will be demonstrated during the coming flight test program. The design philosophy was established up front, with engineers and pilots working closely together. This dedicated team has worked through numerous design challenges to get the F-22 to where it is, and agrees - flying qualities look good!

Maximize Information, Minimize Data

Everyone who works in an office knows that the inverse of this design maxim is often seen. E-mail, voice mail, and the near compulsive desire to print copies and distribute them to the world often leaves people swamped in data from which we must divine information. The F-22 design team has worked hard to turn this axiom of the computer age around and provide the F-22 pilot with information, while tasking the computer to organize the data and present as coherent information to human occupant.

The cockpit displays are set up to be intuitive to the pilot. Confirmed enemy aircraft are red triangles, friendly aircraft are green circles, unknown aircraft are yellow squares, and wing men are shown as blue F-22s.

One of the original objectives for the F-22 was to increase the percentage of fighter pilots who make 'kills'. The Inter/Intra Flight Data Link (IFDL) is one of the powerful tools that make all F-22s more capable. Each F-22 can be linked together to trade information without radio calls with each F-22s in a flight or between flight. Each pilot is then free to operate more autonomously because, for example, the leader can tell at a glance what his wing man's fuel state is, his weapons remaining, and even the enemy aircraft has targeted. Classical tactics based on visual identification and violent formation maneuvers that reduce the wing man to 'hanging on' may have to be rethought in light of such capabilities.

Targets can be automatically prioritized and set up in a shoot list with one button push. A SHOOT cue in the head up display (HUD) alerts the pilot to the selected weapon kill parameters and he fires the weapons. Both a pilot's and wing man's missile flight can be monitored on the cockpit displays.

Considerable effort has been expended in making the F-22 'user friendly'. The aircraft systems operations are straightforward and simple. The airplane can be flown with carefree abandon, and the tactical situation can be understood and acted upon through intuitive presentations from many sensors.

Synergistic Combined Effects of Stealth, Supercruise, and Integrated Avionics

If you look at how the traditional and non traditional elements of the F-22 add up, synergistic effects like these can be seen.

A conventional fighter is equal to, or, in some cases, less capable, than the best enemy fighters. In mock combat with real aircraft or in simulators, it is found that neither enemy or friendly aircraft has the 'edge', or advantage. The enemy sees us at the same time we see him. We both fire at the same time and both airplanes go down or, in the exact military language, we have 'parity'.

Parity is neither politically or militarily acceptable. Politically, because the U. S. can never build the numbers of fighters to overwhelm an enemy by sheer force of numbers (the so-called 'bludgeon' approach to war) and because Americans abhor any losses of its fighting men and women.

Militarily, 'parity' violates the most basic of tenets - attack with overwhelming superiority, which is the capability that the F-22 will provide.

Three Tools

The pragmatic way to determine the capability of the F-22 would be to send it into a full scale war and see how it does. That would be effective, but clearly isn't practical.

The trick is in using three program tools and the power of the computer to simulate war, yet are credible representations of the 'real world'. Three tools currently exist to create that 'crucible of war' evaluation.

Once reserved for hobbyists, war gaming has become a sophisticated, computer based simulation that allows modeling of enemy and friendly weapons and tactics. The advantages are obvious. Once modeled, virtually unlimited numbers of aircraft, missiles, guns, and radars can be added to hypothetical scenarios.

The F-22 can be flown through this computerized combat zone at relatively little cost and over a short period of time. Many scenarios can be explored and statistical results obtained. More than 10,000 of these runs can be made per day. To date, more than 1,000,000 simulator 'battles' have been fought using this tool. Of course, these still remain models of reality and they do not include human operators of the F-22 and the enemy equipment.

The F-22 program uses two simulators, one in Marietta, Ga., and the other in Fort Worth, Texas, to study the effectiveness of the F-22 using real pilots. These simulators combine some of the advantages of war gaming (the large number of enemy aircraft, defenses, and targets) with the variability and unpredictable nature-of the human operator.

In the Air Combat Simulator (ACS), up to 12 F-22 pilots flying simulated F-22s and enemy aircraft can fight each other. Ground controlled intercepts can be directed by four human operators, and the computers can model as many as 80 other aircraft and 80 surface to air missiles can join in this air battle.

While a step closer to reality, the ACS still uses a model of the F-22 and, except for the 16 human operators, all other airplanes and defenses are computer models of what human operators would do. (See ACS in the Other Testing section).

Flight Test

The F-22 represents the real world and, as such, the sensors, the aircraft's performance, its stealth, supercruise and, most importantly, its pilot's performance, will be what will really enter the combat fight. Unfortunately, it is not possible to actually test the F-22 against a large numbers of enemy aircraft and defenses as is done in the Ops Analysis and ACS. The approach that is being used in the F-22 program is to verify or validate the Ops Analysis and ACS predictions using the results from the F-22 flight test program.

Synthesis of the Tools

The three tools represent a spectrum of decreasing battlefield complexity but an increasing involvement of humans and real hardware. Interestingly, no single tool can be used to ascertain F-22 effectiveness as each is, in some unique way, 'limited'. The problem is one of establishing a credible simulation of warfare.

To do this, several simplified scenarios will be flown in each of the three tools and results compared. The Ops Analysis and ACS simulations will be 'tweaked' until they match the real F-22's capabilities. With a level of confidence established that the simulations represent the real F-22, the confidence that results from the more complex war scenarios in the ACS and Ops Analysis are credible.

Flight Test Program

The flight test program will, of course, be the first look at the real F-22. Although the team built and flew the prototype YF-22s and gained quite a bit of knowledge about the technologies involved, there have been some significant changes in the design for the production F-22s.

The YF-22 and the F-22 are similar in shape but there are a number of differences. Externally, the wing sweep has been reduced eight degrees (from 48 on the prototype to 42 degrees on the F-22) and the canopy has been moved forward seven inches and the inlets have been moved aft 14 inches to increase the pilot's visibility. The wing trailing edge and horizontal stabilator shape have been changed for low observability reasons as well as structural strength and aerodynamic refinements. The prominent vertical tails of the prototype have been reduced in size by approximately 20 percent.

Internally, the F-22 has all new subsystems based on the prototype's approach, built to an 8,000 hour service life. While the YF-22's were essentially engine and airframe demonstrators, the F-22A has complete sensor and weapons capability. The aircraft is fully self contained for starting and can use its Auxiliary Power Unit (APU) to perform most maintenance tasks.

In addition to a screwdriver and wrench, the F-22 maintainer will also carry a laptop sized computer. The maintainer accesses the F-22 by a laptop sized computer called a Portable Maintenance Aide (PMA) that can read and record aircraft consumables like fuel and oil, but can also control aircraft systems during maintenance, as well as upload new Operational Flight Programs (OFPs), computer software to run the aircraft. (See PMA in the Supportability section).

There are nine single seat F-22As in the basic EMD test program. First flight is scheduled to take place from Dobbins ARB in Marietta, Ga. followed by six to eight airworthiness flights prior to the ferry flight to the Air Force Flight Test Center at Edwards AFB, Calif. The test program runs for five years and consists of approximately 2,700 flights and 7,800 hours.

The first three F-22 aircraft are essentially engines and airframes and do not have the full up tactical avionics and sensors. They will be used for envelope expansion, structural loads, propulsion, and weapons, and other flight test areas such as high AOA flights and arresting gear tests.

The remaining six F-22s are interchangeable avionics test aircraft. The avionics suite will mature through four stages or 'blocks' of avionics, however, each of the six avionics aircraft will all carry the same configuration of avionics at the same time. This allows any airframe to be used for any avionics test and not lose a test flight maintenance down days or modifications on a particular airframe.

The combined test force (CTF) will start at about 290 people and build to a maximum of 650 in 2001. Initially the CTF will comprise a 60/40 percent mix of contractor and Air Force personnel. As testing progresses, the mix will shift to a 50/50 mix. The organization will be commanded by an Air Force officer, with a contractor deputy. The internal organization is built around the Integrated Product Teams (IPTs) that produce the flight test product - data.

The Airworthiness IPT is permanent at Marietta, Ga. and is responsible for taking the F-22s from manufacturing through initial ground tests, first flight, air worthiness, and ferry to Edwards.

The Air Vehicle IPT is responsible for all tests on the first three aircraft while the Avionics IPT does the same for the six avionics test aircraft. All other participants support these IPTs so that test pilots receive their assignments from flight operations but work directly for the IPT when conducting flight tests.

Air Dominance for the 21st Century

The history of air power shows that there are periods of incremental evolution and refinement of a basic configuration, as was seen in the first fifty years of flight where the propeller driven airplane was refined to its ultimate expression in World War II fighters. At some point, however, a truly revolutionary breakthrough occurs that overshadows current aircraft and leads to a new period of evolution and refinement of this revolutionary change. The jet engine represents that first revolutionary jump. The F-22 Raptor represents the next revolution in aircraft development.

Interestingly, this revolution is not as visual as the jump from prop to jet, but it will just as profound. The explosion of computer capability now turns warfare into a war of exploiting information and denying it to the enemy. This information will make the F-22, and all other new weapons of war, a leap ahead of current weapons.



Airborne Laser

Key Messages

The Airborne Laser (ABL) will play a vital role in the nation's theater missile defense (TMD) strategy. Under that strategy, the Department of Defense is developing a joint, layered defense architecture against theater ballistic missile (TBM) attack. The ABL will be the primary weapon used to attack TBMs during their boost phase, destroying them early in flight before their warheads have an opportunity to separate from the boost vehicle. Under this scheme, the warheads and destroyed missile components fall on enemy territory, making the aggressor's nation vulnerable to the effects of whatever warhead they employed. As such, the ABL will provide a strong deterrence against the use of weapons of mass destruction. ABL offers revolutionary warfighting capability, taking advantage of existing high energy laser and adaptive optics technology to field a flexible, robust, long-range, and affordable weapon system.

Program Description and Key Points

The ABL is a rapid, self-deployable, long-range, airborne laser weapon ready for immediate employment upon arriving in theater. The program will integrate a multi-megawatt Chemical Oxygen Iodine Laser into a Boeing-747 aircraft to kill boosting TBMs at ranges in excess of several hundred kilometers. It will autonomously detect these threats with on-board infrared sensors, track them with highly accurate, low-power lasers, and fire its high-energy laser to destroy the missile. The high-energy laser beam control system, which uses adaptive optics and fast steering mirrors, will compensate for atmospheric effects and aircraft movement. The ABL will provide missile flight data to include estimated launch and impact points to other TMD architecture systems via an onboard communications suite. The ABL will have a salvo engagement capability, carrying enough chemical fuel to destroy 20 to 40 enemy missiles before refueling.

Contribution to Air Force Core Competencies

The Airborne Laser is an essential component in the Air Force capability to gain and maintain Air and Space Superiority. It fills a critical portion of the layered TMD defense architecture by attacking boosting TBMs. ABL will support Air Force efforts to provide Rapid Global Mobility forces to the CINCs. From its base in the continental U.S., the large 747-400 airframe carries all ground support, laser fuel, and support personnel needed to provide a rapid theater ballistic missile defense for deploying troops. The ABL also complements our Precision Engagement capability through precise, long-range detection, tracking, and targeting of boosting TBMs, then destroying them using its high energy laser. Finally, ABL contributes to gaining and maintaining Information Superiority using its onboard sensors and information systems to provide relevant TBM information to other components of the TMD architecture. ABL is being designed to integrate in the

Agile Combat Support structure. ABL's logistics support concept will take full advantage of the extensive worldwide commercial support structure and maximize use of existing commercial and military hardware and software.

Discussion

The ABL is a revolutionary weapon system that can dramatically alter future battles. Its unique counter air capabilities to destroy TBMs during the boost phase will ensure our nation's military forces, and those of our allies, will operate independent of theater ballistic missile attack. Complementing Joint Strike Fighter and F-22 efforts to destroy theater ballistic missiles and their support equipment on the ground before launch, the ABL will engage missiles that are not destroyed during attack operations.

Air Combat Command will operate ABL from a continental U.S. base and will rapidly deploy it around the globe to arrive in theater, combat ready. Seven aircraft are currently planned; five aircraft are required to support two high-altitude Combat Air Patrol (CAP) orbits. At any given time, two aircraft will be on CAP, two aircraft will be preparing to arrive on CAP, and one aircraft will be on ground alert. The remaining aircraft will be allocated for training and/or depot maintenance. The joint forces air component commander (JFACC) will locate ABL orbits based on the threat, rules of engagement, weather conditions, and intelligence information. Inflight refueling and rotation of aircraft will provide continuous 24-hour coverage of potential TBM launch sites. Normal station time is 12 hours, but ABL can maintain station for up to 22 hours.

Program Status

The ABL program is an ACAT ID, Major Defense Acquisition Program in the Program Definition and Risk Reduction (PDRR) phase of its acquisition cycle. The Air Force awarded a \$1.1 billion, 74-month contract to Boeing in November 1996. The program is event driven and structured to progressively address major program risks before major funding commitments. The integrated program schedule illustrates the 11-year research and development effort followed by a short production run. The research and development costs total \$2.5 billion, and production costs are estimated to be \$3.7 billion in then-year dollars.

Laser Focus World

Air Force Completes Airborne Laser Tests--February 10, 1995

Replicated missile components were used as targets in a series of tests conducted on the Mid-Infrared Advanced Chemical Laser at White Sands Missile Range in New Mexico. During the tests, which are part of the Airborne Laser program at Phillips Laboratory (Albuquerque, NM), half- and full-scale replicas of Scud-type missile fuel tanks were hit by the laser at various powers and spot sizes. Information gained from these tests, which concluded last month, will be used to determine the power of the laser and the size of the beam on the target's surface to ensure its destruction.

"On the tests conducted thus far, we were able to demonstrate catastrophic structural failure on the full-scale replicas' fuel tanks," said Col. Richard D. Tebay, director of the Airborne Laser Program Office. "Although the tests were conducted on the ground, conditions were very representative of a nominal Airborne Laser engagement. And, once we determine the power and spot size, we can focus engineering attention on fine-tuning the laser design."

Last May, Phillips Laboratory awarded contracts totaling nearly \$44 million to two industry teams for designs of advanced-technology demonstrators and fully operational weapon systems. One team consists of Boeing, TRW, and Lockheed; the other is made up of Rockwell International, Hughes, and E-Systems. Both teams are conducting parallel development efforts.

Advanced Concept Technology Demonstrations (ACTDs)

Medium Altitude Endurance UAV, Predator

Program Description

The Medium Altitude Endurance Unmanned Aerial Vehicle (MAE UAV), Predator, provides affordable medium altitude reconnaissance and surveillance with a rapid deployment capability. Current national, theater, and tactical intelligence collection assets do not provide for long dwell, releasable near-real-time intelligence information on fixed and mobile targets for the in-theater CINC, Joint Force Command (JFC), and the National Command Authority (NCA).

The Predator is fully autonomous, low cost/attractable, and interoperable with the current architecture. The design has achieved an air vehicle fly-away cost of less than \$4 million. The Predator provides a near-term capability with potential cueing from satellites, Joint Surveillance Target Attack Radar System (Joint-STARS), U-2s, RIVET JOINT, and AWACS. The system takes advantage of available technology to provide continuous, near all-weather day/night coverage with EO/IR and SAR sensors and produces releasable/unclassified image products. The Predator can operate untethered and ground control is only needed for updating its activities. It is ideally suited for continuous observation over lightly defended areas when rapid deployment is necessary. The Predator will operate under the Operational Control (OPCON) of the JFC.

System Objective/Parameters

The first objective of the Predator ACTD was to quickly satisfy military need by providing a deployment capability within the 30-month ACTD time frame. The second principal objective was to develop concepts of operation for endurance UAVs in general. This program stresses COTS system integration in order to meet its low cost requirement. Off-the-shelf EO, IR, SAR, navigation, systems, engines, and basic aircraft design were integrated to produce Predator. The SAR is based on previous development from the A-12 program but was repackaged to fit the Predator. The EO/IR sensors are rated at National Imagery Interpretation Rating Scale (NIIRS) 6 or better and the SAR sensor has 1 foot resolution. The Predator can operate under most weather conditions with a range in excess of 500 nautical miles from the launch area at altitudes ranging from 3,000 to 25,000 feet Mean Sea Level (MSL). The Predator can loiter for 24 hours at its 500 nautical mile range or over an area covered by 40 hours of flight time. It is supported by transportable ground control vans which are equipped with both line-of-sight (LOS) (C-band) control for an operating range greater than 148 nautical miles (demonstrated in Bosnia) and SATCOM (UHF and Ku-Wideband) relay for beyond line of sight ranges. The system is highly mobile, transportable by C5, C-141, or C-130 aircraft and can be operational six hours after arrival. The Predator CONOPS is portrayed in Figure 2-11.

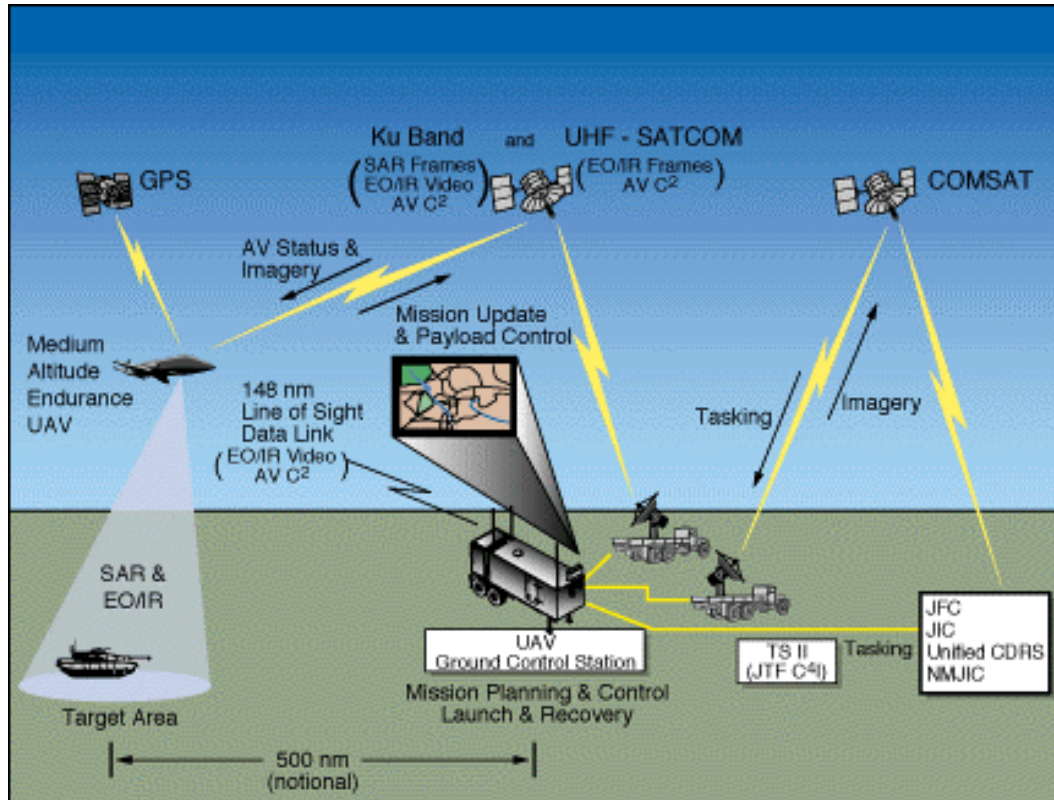


Figure 2-11: Predator CONOPS

Future Plans

Based on the accomplishments, future plans for the Predator ACTD with an associated timeline include:

- identifying potential upgrades such as de-icing, UHF radio, etc.;
- identifying and prioritizing future payload upgrades;
- upgrading all systems to final configuration-June 1996;
- conducting Navy demonstration with Predator controlled from a submarine-June 1996;
- reaching the conclusion of the Predator ACTD-June 1996;
- providing program support for exercises/demonstrations; and
- conducting exercises/demonstrations as needed.

UAV Annual Report, 1996

General

Predator, also identified as the Medium Altitude Endurance (MAE) or Tier II UAV, is a derivative of the Gnat 750 (Tier I) UAV. In July 1996, Predator completed its 30-month ACTD program and is transitioning to low-rate initial production (LRIP) in the formal acquisition arena. The system provides long-range, long-dwell, near-real-time imagery intelligence (IMINT) to satisfy reconnaissance, surveillance and target acquisition (RSTA) mission requirements. The air vehicle carries both EO/IR and SAR sensors which, with Ku- as well as UHF-band satellite communication (SATCOM) links, enable the system to acquire and pass imagery to ground stations for adverse weather, beyond-line-of-sight (BLOS) use by tactical commanders. Recent addition of de-icing equipment now allows transit and operation in adverse weather conditions. This capability was deployed to Bosnia in October 1996. As production assets augment ACTD assets, Predator will be the operational endurance UAV workhorse for the next several years. Prime contractor is General Atomics - Aeronautical Systems, Inc., San Diego, CA.



SUBSYSTEMS

- 4 Air Vehicles
- 1 Ground Control Station
- 1 Trojan Spirit II Dissemination System
- Ground Support Equipment

KEY OPERATIONAL FACTORS

- Sensors: EO, IR, and SAR
- Deployment: Multiple* C-130 sorties
- Radius: 926 km (500 nm)
- Endurance: >20 hrs
- Max Altitude: 7.6 km (25,000 ft)
- Cruise Speed: 120-130 km/hr (65-70 kts)

*Depends on equipage and duration

Flight Data

· Flights / Hours: Bosnia 159 / 1,169

After a November 1995 return from Albania and support of United Nations operations in Bosnia, Predator AVs incorporated both a SAR sensor (with imagery transmitted through the Ku-band SATCOM link) and initial ice sensing features to enable poor weather operation. Predators redeployed in March 1996 to Taszar, Hungary, supporting NATO operations in Bosnia; return is currently planned for February 1997. Concurrently, other Predators participated in a succession of interoperability demonstrations, specifically with the U.S. Customs Service (Fall, 1995), a Navy carrier battle group (CVBG) (Fall, 1995), and a Navy submarine with SEAL team aboard (Spring, 1996); details are on pages 32-33.

On 30 June 1996, Predator completed its 30-month ACTD. On 26 July, General Atomics received a \$23 million contract for another five AVs and ancillary equipment. On 2 September, the Air Force Air Combat Command's 11th Reconnaissance Squadron, Nellis AFB, NV, assumed operational control (OPCON) of assets.

“The Predator has proved its ability to provide a significant and urgently needed reconnaissance capability in many mission areas and the continued participation of each Service must be maintained.”

Dr. William J. Perry, SecDef

Memo for Secretaries of the Military Departments (et al.)

on Assignment of Service Lead for Operation of the Predator UAV, 9 April 1996

Providing Multi-Role Support to All Operational Echelons

In the Defense Appropriations Act for FY 1997, the Congress transferred Predator's production funding from the Defense-wide Procurement account to the Navy's Procurement account and increased the amount by \$50 million to \$115.8 million for the year (which included funding for U-CARS integration on Predator and Outrider).

Remarks

De-icing system - Required for reliable all-weather operation

Onboard UHF voice radio - For BLOS communications with ATC

Improved identification friend or foe (IFF) - Positive airborne control requirement

Engine upgrade - Rotax 914 to replace Rotax 912

Heavy fuel engine (HFE) - Mandatory for a marinized Predator UAV

Common Auto Recovery System (U-CARS) - Feasibility study to be completed Dec 96

Engine and propeller quieting - Exhaust system muffler, variable-pitch prop

Upgraded IR sensor - Under study for near-term P3I

Moving target indication (MTI) - Under study for near-term P3I

Improved GPS - Under study for longer term

SATCOM suite (Trojan Spirit) replacement - Under study for longer term

Upgraded GCS communications suite - Under study for longer term

Communications relay - Under study for longer term

Laser designation/rangefinder - Under study for longer term
SIGINT payload - Under study for longer term

“The operational capabilities embodied in the Predator UAV system are a significant first step toward the continuous, real-time Reconnaissance, Surveillance and Target Acquisition (RSTA) required by 21st century joint warfighters. ACC is committed to developing our ability to employ the family of UAVs in that role.”

General Richard E. Hawley
Commander, Air Combat Command
August 1996



Advanced Uninhabited Concepts

This design area utilizes Northrop Grumman's experience in manufacturing and developing uninhabited aerial vehicles for the U.S. and worldwide markets, as well as expertise in precision strike to create affordable uninhabited air vehicles for future military requirements.

The most immediate system-level opportunity is the evolving DARPA/Air Force Uninhabited Combat Air Vehicle program to develop a small, unmanned, stealthy strike aircraft for lengthy or extremely dangerous missions, such as the suppression of enemy air defenses.

Northrop Grumman is funding research and development of a next-generation uninhabited air vehicle concept for use in the 21st century as a low-cost, stealthy, reusable, precision strike weapon system.



DarkStar UAV

The DarkStar unmanned aerial vehicle, a prototype developed by the team of Boeing and Lockheed Martin Skunk Works, successfully completed its first flight on Friday, March 29, 1996. The 20-minute flight took off from Edwards Air Force Base, Calif., at 6:25 a.m. (PST). DarkStar reached an altitude of 5,000 feet and completed basic flight maneuvers. Boeing and Lockheed Martin are developing the low-observable, high-altitude UAV -- with a fuselage length of 15 feet and a wingspan of 69 feet -- for the Department of Defense. Powered by a single turbofan engine, it can operate at ranges greater than 500 nautical miles and loiter for more than eight hours at altitudes greater than 45,000 feet. DarkStar's mission will be to penetrate aggressively defended airspace.



FACT SHEET

AGM-88 HARM

Mission

The AGM-88 HARM (high-speed antiradiation missile) is an air-to-surface tactical missile designed to seek and destroy enemy radar-equipped air defense systems.

Features

The AGM-88 can detect, attack and destroy a target with minimum aircrew input. The proportional guidance system that homes in on enemy radar emissions has a fixed antenna and seeker head in the missile nose. A smokeless, solid-propellant, dual-thrust rocket motor propels the missile. The F-16C has the capability to employ the AGM-88, and is the only aircraft in the current inventory to use the AGM-88.

Background

The AGM-88 missile was approved for full production by the Defense Systems Acquisition Review Council in March 1983.

The Air Force equipped the F-4G Wild Weasel with the AGM-88 to increase the F-4G's lethality in electronic combat. The missile worked with the APR-47 radar attack and warning system on the aircraft.

The missile is operationally deployed throughout the Air Force and in full production as a joint U.S. Air Force-U.S. Navy project.

General Characteristics

Primary Function: Air-to-surface anti-radiation missile

Contractor: Texas Instruments

Power Plant: Thiokol dual-thrust rocket motor

Thrust: Dual thrust

Length: 13 feet, 8 inches (4.14 meters)

Launch Weight: 800 pounds (360 kilograms)

Diameter: 10 inches (25.40 centimeters)

Wingspan: 3 feet, 8 inches (101.60 centimeters)

Range: 30 plus miles (48 plus kilometers)

Speed: Supersonic

Aircraft: Used aboard the F-16C

Guidance System: Proportional

Warheads: High explosive

Unit Cost: \$200,000

Date Deployed: 1984

Point of Contact

Air Combat Command, Public Affairs Office; 115 Thompson Street, Ste 211; Langley AFB, Va. 23665-1987; DSN 574-5014 or (757) 764-5014.

Facts on Demand #1107

March 1997





Joint Direct Attack Munition (JDAM)

The Joint Direct Attack Munition (JDAM) is a guidance kit that converts existing unguided free-fall bombs into precision-guided "smart" munitions. By adding a new tail section containing global positioning system (GPS)/inertial navigation system (INS) guidance control unit to existing inventories of Mk-83 and BLU-110 1,000-pound bombs, and the Mk-84 and BLU-109 2,000 pound bombs, the cost-effective JDAM will dramatically improve the accuracy of precision strike munitions in adverse weather. JDAM can be dropped by an aircraft from up to 15 miles from the target. Updates from GPS satellites will help guide the bomb to the target.

The JDAM production team includes Lockheed Martin Tactical Defense Systems for the mission computer, Honeywell Inc. for the inertial measurement unit, Rockwell Collins for the global positioning system receiver, HR Textron for the tail actuator subsystem, Lockley for the tail fairing, Enser and Eagle-Picher for the battery, and MDI and Lambda for the power supply.

The team has completed a \$45 million contract for pre-engineering and manufacturing development (EMD). Throughout the pre-EMD the team consistently met or exceeded all major milestones ahead of schedule and below cost. The end result was a JDAM design that will exceed all reliability, maintainability and support requirements. Boeing has provided a 20-year warranty on JDAM at no charge to the customer. In addition, the design is guaranteed to be maintenance free for its 20-year life and implementation will require no new support equipment or skills.

JDAM is currently in the engineering, manufacturing and development phase of a \$70 million joint Air Force, Navy, Marine Corps program. JDAM is one of seven pilot programs selected by the U.S. Department of Defense to test methods for streamlining the acquisition process. No military standards or specifications were applied to the JDAM

program and, by incorporating the use of commercial practices and off-the-shelf components where practical, the team was able to significantly improve the system's affordability. On May 29, 1996, the JDAM team was awarded the prestigious Acquisition Lightning Bolt Award by Mr. Arthur Money, Assistant Secretary for the Air Force for Acquisition.

On April 30, 1997, the Air Force announced the decision to initiate low-rate initial production (LRIP) of JDAM, with the first production lot of 937 JDAM kits. The JDAM Integrated Product Team achieved a phenomenal 53 guided JDAM weapon releases in the six months prior to the LRIP decision. JDAM demonstrated high reliability and outstanding accuracy. Twenty-two of the weapon releases were accomplished during an early Air Force operational assessment. Over a four-week period operational crews put JDAM through an operationally representative evaluation, including targets shrouded by clouds and obscured by snow. All 22 weapons successfully performed up to their operational requirements including overall accuracy of 10.3 meters, significantly better than the 13 meter requirement.

JDAM has successfully accomplished guided releases from the F/A-18, F-16, and B-2 aircraft. Integration is ongoing with the B-1B, B-52H, and AV-8B.

The Department of Defense plans to buy 87,496 JDAMs for use by the Air Force and Navy under a production program that is expected to continue well into the next century. The estimated overall value of the program exceeds \$2 billion.



GPS Aided Munitions (GAMs)

The Northrop Grumman B-2 is the only aircraft in existence to combine long range, large payload, precision weapons and stealth technology in one platform.

U.S. based B-2s can strike virtually any point in the world within hours, in adverse weather conditions, carrying effective, powerful precision weapons. The B-2 Spirit can hedge against a surprise attack abroad and allow the U.S. military to project decisive military power, even when foreign bases are unavailable.

The current program calls for the delivery of 21 fully-operational B-2 bombers to the Air Force's 509th Bomb Wing at Whiteman Air Force Base, Missouri. The first B-2 was delivered to the 509th on December 17, 1993, and the final one is scheduled for delivery before the end of the century.

<Picture: GAM-113>B-2s have combined the power of the Global Positioning System (GPS) with two key technologies: the aircraft's own GPS-Aided Targeting System (GATS) and the U.S. Air Force's GPS-Aided Munition (GAM) to turn existing 2,000 lb general-purpose bombs into precision weapons.

On October 8, 1996, the U.S. Air Force used three B-2s to conduct a live weapons demonstration of the GATS/GAM system delivering 16 weapons to 16 separate targets on a single pass from an altitude of approximately 41,000 feet and a down-range distance of more than six miles. All 16 targets were destroyed.

In April 1997, the B-2 Spirit reached its initial operational capability (IOC).

" Today our nation's deterrent force has been enhanced significantly. This is a high-leverage weapon system..."

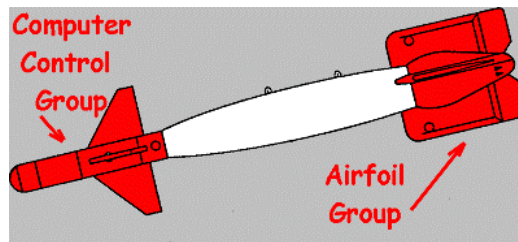
General Eugene E. Habiger, Commander in Chief,
U.S. Strategic Command, Initial Operational Capability Announcement, April 1997

“Smart” Bombs

Laser Guided Bombs (LGBs)

A Laser Guided Bomb (LGB) is a maneuverable free-fall weapon that guides to a spot of laser energy reflected off of the target. The LGB is delivered like a normal low-drag bomb and then the warhead and guidance unit corrects for many of the normal small errors inherent in any delivery system. Laser designation for the weapon can be provided by an airborne or ground laser designator.

The LGB consists of a laser guidance kit that attaches to the nose and tail of the standard GP, blast, or penetrator warheads. The GBU-10 is a kit attached to the MK-84 (2000 pound class) warhead. The GBU-12 is a kit attached to the MK-82 (500 pound class) warhead. LGB's are not active until after release and require no modifications or electrical interface with the delivery aircraft. The laser guidance kit consists of two major components that are attached to the warhead:



The Computer Control Group (CCG). This represents the "eyes" of the weapon. A laser spot seeker is incorporated to receive and process the laser energy. The seeker head aligns with the airstream and sends guidance signals to the canards.

The Air Foil Group (AFG) consists of a tail-mounted wing assembly that stabilizes the bomb inflight and smooths the action of the canards.



GBU-24A/B Paveway III Laser Guided Bomb

Length:14 ft (4.3 m)

Diameter:15 in (377 mm)

Tailspan:6.5 ft (2 m)

Weight:2000 lbs (900 kg)

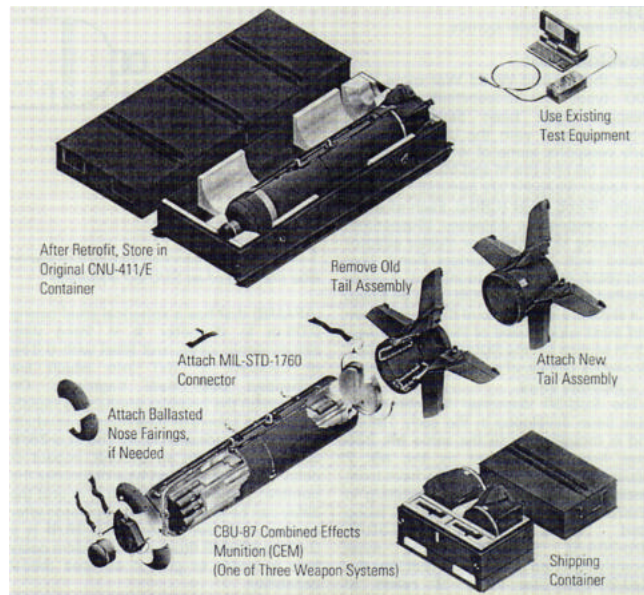
Filling:530 lbs (240 Kg) of Tritonal

Guidance: Infrared laser

The GBU-24/B was originally designed to be installed on the MK-84 General Purpose Bomb. In 1985 with the availability of the BLU-109/B Penetrator bomb the Paveway III was made to adapt it and thus was redesignated GBU-24A/B.

GBU stands for Guided Bomb Unit in some books and as Glide Bomb Unit in others.

The difference between the Paveway II and the Paveway III is that the Paveway III can be released at a lower altitude as it will do a "bump-up" maneuvers by climbing 500 feet (because of its large tail assembly which provides it with enough lift to do so) or so to be able to detect the target then dive on it.



Wind Corrected Munitions Dispenser (WCMD)

WCMD is a guidance kit for tactical munitions dispenser weapons such as the Sensor Fuzed Weapon (SFW), Combined Effects Munition (CEM), and Gator. Alliant is the current producer of CEM and Gator systems for the U.S. Air Force, and is the largest supplier of munitions to the U.S. Department of Defense.

The guidance kit enables the weapon to be accurately delivered from all altitudes and in adverse weather. It is especially important because it adds a conventional capability for the U.S. Air Force long-range bomber force.

Wind Corrected Munitions Dispenser (WCMD)

A low-cost retrofit that provides accurate, all-weather submunition delivery from a wide range of altitudes



The Wind Corrected Munitions Dispenser (WCMD) is an inertially guided tail kit that will replace the existing tails on a portion of the Combined Effects Munition, Gator, and Sensor Fuzed Weapon area cluster munitions. The new tail kit will enable the weapons to be launched in adverse weather by both fighter and bomber aircraft from medium to high altitudes and will eliminate the effects of wind, launch transients, and ballistic errors to achieve greatly improved accuracy.

The existing Cluster Bomb Unit (CBU) inventories of Tactical Munitions Dispenser (TMD) and submunition systems will not

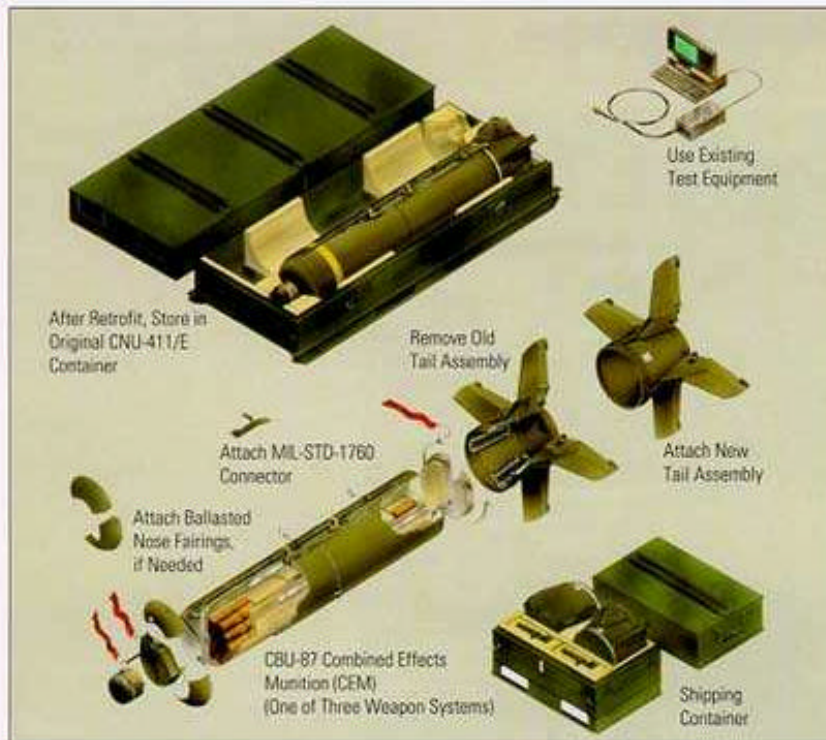
require any design modification and will retain their existing operational capabilities. A common WCMD tail kit is designed for adaptation to the existing weapon, making retrofit of existing inventories affordable.

Key Benefits

- All-weather operation
- Increased high-altitude accuracy
- Independent targeting

Teamed for Success

For the WCMD program, Alliant Techsystems has teamed with Texas Instruments. Alliant is prime contractor and will have lead responsibility for weapon system integration and assembly. The Defense Systems & Electronics Group of Texas Instruments will provide inertial guidance, mission planning, and aircraft integration. Subcontractors include Abex NWL, which will provide the control actuator system, and Kearfott Guidance and Navigation, which will provide the inertial sensor assembly.



Wind Corrected Munitions Dispenser (WCMD) Advantages

Increases Aircraft Survivability

- 200 to 45,000 ft. altitude delivery envelope
- Reduces exposure to enemy air defenses
- Avoids low-level target overflight
- Launch and leave

Reduces Mission Sorties

- Multiple targets per aircraft pass
- Reduces number of weapons needed per mission

Improves Area Weapon Effectiveness at Low Cost

- Low development and procurement cost through application of Integrated Product Team process and commercial practices
- Easy retrofit to current inventory
- No scheduled maintenance
- Rapid inventory insertion
- Low life cycle cost (all-up round)
- No new ground support equipment required

Improves Tactical Flexibility

- Provides bomber (B-52, B-1, B-2) and fighter (F-15, F-16, F-117) capability
- Effective against a wide spectrum of targets
- Multiple dispenser pattern capability
- Compatible with all current TMD payloads
- All-weather operation

WCMD

Wind Corrected Munitions Dispenser

Wind Corrected Munitions Dispenser turns existing general purpose cluster munitions (CBU-87, -89, and -97) into inexpensive all-weather precision guided weapons. By correcting for launch transients, ballistic errors, and winds aloft, Martin Marietta's WCMD provides strike aircraft with a precision pattern lay-down capability for cluster munitions from any altitude and in any weather condition.

Now in development, this next generation, low-cost precision munition kit consists of an inertial guidance unit, active control surfaces, and unique wind estimation and compensation algorithms.

Our "one kit fits all" approach provides a MIL-STD-1760 interface, common retrofit kit hardware, and common mission planning software for all CBUs. Each weapon can be independently targeted to achieve maximum operational effectiveness.

Affordability is a driving factor in Martin Marietta's WCMD design. A high level of commonality with the Joint Direct Attack Munition (JDAM) and our team's aggressive implementation of Design and Manufacturing producibility initiatives have dramatically reduced kit parts count and assembly time to provide a very low average unit production price.

Low cost of ownership and maximum logistics flexibility are provided by our easy field-retrofit procedures, wooden round logistics concept, and product warranty. The single kit configuration minimizes physical inventory, storage, training, and supportability requirements.



MARTIN MARIETTA

Wind Corrected Munition Dispenser

Designed, Built, and Tested

Improved Operational Flexibility and Survivability

- Autonomous, all-weather attack operations
- Compatible with all Air Force strike aircraft
- All-altitude and off-axis delivery
- Preplanned and in-flight mission planning

High Lethality

- Independently programmable for attacking multiple targets per pass
- Real-time wind compensation to achieve accurate dispense point
- Precision ground footprint placement and submunition density

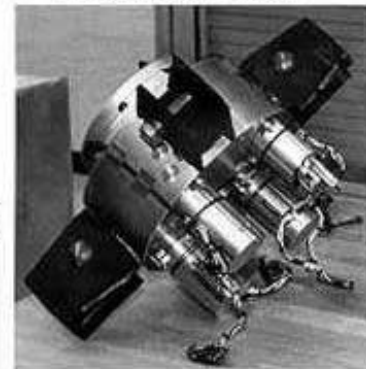
Low Cost of Ownership

- Common field-retrofit kit for inventory weapons
- Low unit price, wooden round logistic concept, product warranty, and high commonality with JDAM



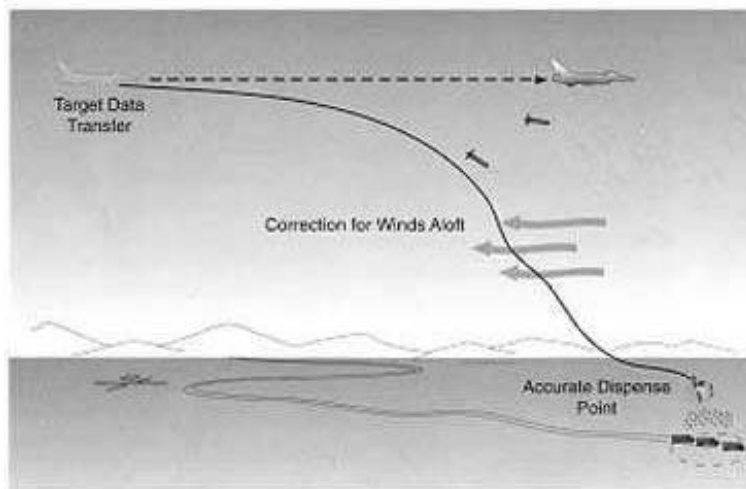
Guidance Control Unit

Control Actuation System



Operational Data

Specified Accuracy	CEP 100 feet
Mission Planning	Common AFMSS module
Aircraft Compatibility	F-15E, F16, F117 B-1, B-2, B-52 MIL-STD 1760
CBU Compatibility	CBU-87/B CEM, CBU-89/B GATOR, CBU-97/B SFW



Operational Concept

After initialization from the aircraft's inertial platform, each WCMD autonomously guides itself to a mission-planned dispense point to accurately laydown submunitions over the desired ground targets.

Martin Marietta Electronics & Missiles

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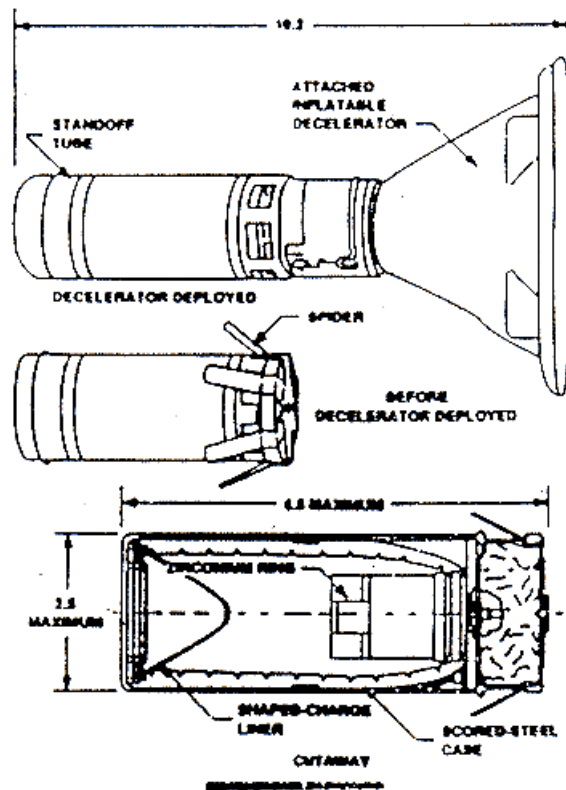
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CBU TYPES

ALL THREE CBU_s LOOK THE SAME ON THE EXTERIOR (THE EXTERIOR IS A TACTICAL MUNITIONS DISPENSER aka TMD), IT IS WHAT SUBMUNITIONS (OR CLUSTERS OF BOMBS, ie CLUSTER BOMB UNITS) THAT ARE CONTAINED INSIDE THAT DIFFERENTIATES THEM

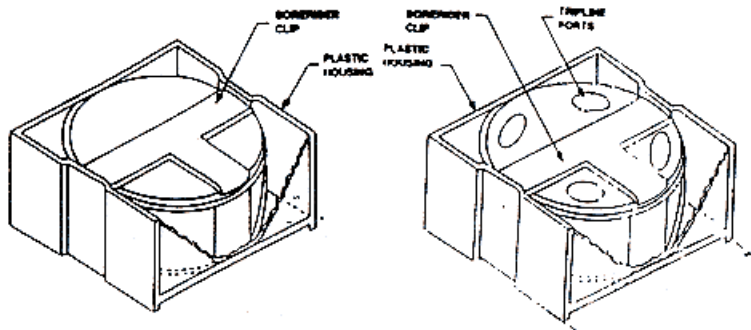
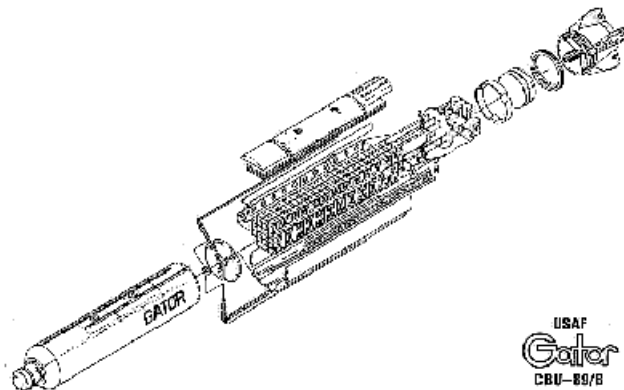
- CBU 87 Combined Effects Munition (CEM)**

- Contains 202 BLU-97/B bomblets, each containing a shaped charge, scored steel casing and zirconium ring for anti-armor, fragmentation and incendiary capability



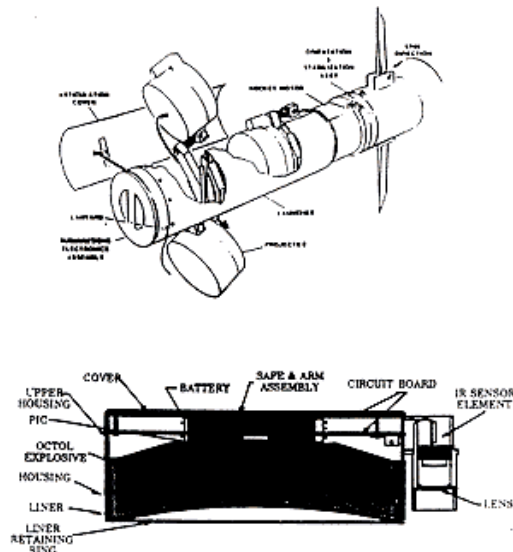
CBU 89 Gator

- Contains 72 Magnetic Sensing BLU-91/B anti-tank mines and 22 trip wire activated BLU-92/B anti-personnel mines.

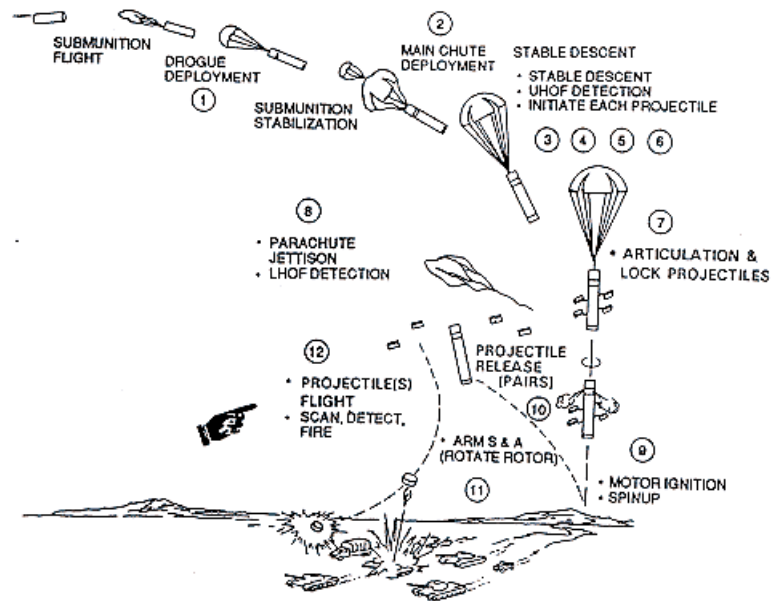


CBU 97 Sensor Fuzed Weapon (SFW)

- Contains 10 BLU-108/B sub-munitions, each containing four (4) Skeet (40 per SFW CBU).
- Designed to provide multiple kills per pass capability against tanks, APCs, Artillery and support vehicles.



CBU 97 Sensor Fuzed Weapon (SFW) Deployment Sequence





Since the beginning of aerial warfare, darkness has hampered aircraft attacks against ground targets. Then the Low-Altitude Navigation and Targeting Infrared for Night (LANTIRN) system revolutionized night combat for tactical fighter aircraft: LANTIRN turned night into day.

LANTIRN is a high-performance navigation and targeting system for the U.S. Air Force F-15E and F-16C/D, international aircraft, and under consideration for the U.S. Navy F-14. LANTIRN permits fighter pilots to operate anywhere in the world, in daylight or in total darkness, at speeds exceeding 500 miles per hour and at altitudes beneath enemy radar detection, for precision attack of ground or naval targets. LANTIRN is also effective at medium and higher altitudes, providing impressive system flexibility.

During Operation Desert Storm, LANTIRN-equipped F-15 and F-16 aircraft consistently and successfully penetrated air defenses to deliver laser-guided and conventional munitions from varying altitudes with unprecedented accuracy. Lockheed Martin and the U.S. Air Force are working to further enhance LANTIRN performance and survivability through an active preplanned product improvement (P3I) program that will keep LANTIRN as the world's premier night attack system into the 21st century.

For international applications, Pathfinder and Sharpshooter are derivatives of the LANTIRN navigation and targeting systems. Each has been integrated and flown successfully on a variety of aircraft. Pathfinder and Sharpshooter have benefited from years of LANTIRN technical development and serve several allied countries.

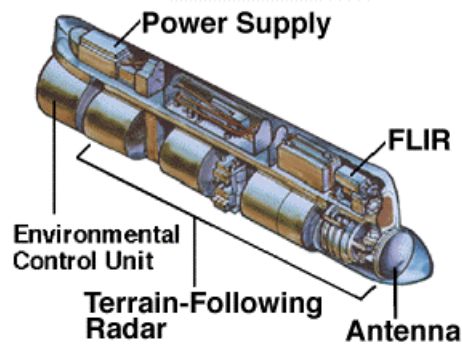
LANTIRN Navigation Pod

The navigation pod's terrain-following radar (TFR) and forward-looking infrared (FLIR) sensor enable pilots to fly during daylight or at night, under the weather, and at very low altitude. The TFR lets pilots maintain a selected altitude over terrain with varying elevation.

The wide-field-of view (WFOV) FLIR provides a visual image of terrain in front of the aircraft, enabling a pilot to maneuver at low altitudes at night over any type of terrain.

The FLIR provides terrain imagery and the TFR provides flight symbology to the pilot's head-up display, enhancing the pilot's visual situation awareness while providing information critical to the highspeed, low-altitude mission.

LANTIRN Navigation Pod



Navigation Pod AN/AAQ-13

Weight	430 lb (195 kg)
Height	21.5 in (54.6 cm)
Width	14.0 in (35.5 cm)
Length	78.2 in (198.5 cm)

Features and Benefits

- WFOV FLIR (21 x 28 degrees) for improved night pilotage
- FLIR snap-look and look-into-turn for enhanced situation awareness
- Multimode Ku-band terrain-following radar for low-altitude navigation
- Automatic or manual terrain-following at pilot-selected altitudes
- Day and night operation with single sensor, improving reliability

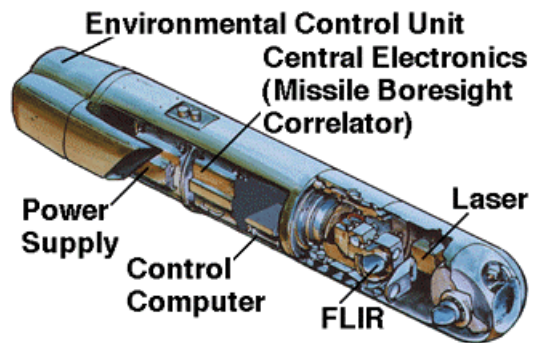
LANTIRN Targeting Pod

LANTIRN's targeting pod is integrated with the aircraft's fire control and internal navigation systems, providing multiple methods to acquire and destroy targets.

In a basic attack scenario, the pilot detects a target using the pod's WFOV FLIR imagery, displayed on the head-down display. The pilot then switches to the narrow-FOV FLIR to magnify the image and engages the target tracker. After target lock-on, a weapon is selected.

For a Maverick missile, the pod automatically hands the target off to the missile for launch with pilot consent. For a laser-guided bomb, the pilot aims the laser designator, and the bomb guides to the target. For a conventional bomb, the pilot can use the laser to determine range, then the pod feeds the range data to the aircraft's fire control system. This enables highly accurate delivery of unguided ordnance.

LANTIRN Targeting Pod



Targeting Pod AN/AAQ-14

Weight	540 lb (245 kg)
Width	15.0 in (38.1 cm)
Length	98.5 in (250 cm)

Features and Benefits

- 8.1-inch-aperture FLIR for long-range target acquisition
- WFOV FLIR (6 x 6 degrees) for target detection and tracking
- NFOV FLIR (1.7 x 1.7 degrees) for target selection and lock-on
- Dual-mode automatic target tracker
 - boresight correlator for automatic IR Maverick handoff
- Eyesafe laser for training

LANTIRN 2000



LANTIRN (Low-Altitude Navigation and Targeting Infrared for Night) is the world's combat-proven precision attack system. More than 1,400 pods are deployed by the US Air Force, Air National Guard and Navy, and nine international air forces. The US Air Force has made a commitment to fly and fight with LANTIRN until 2025. Three hardware enhancements to the targeting pod comprise the basic LANTIRN 2000. These additions are:

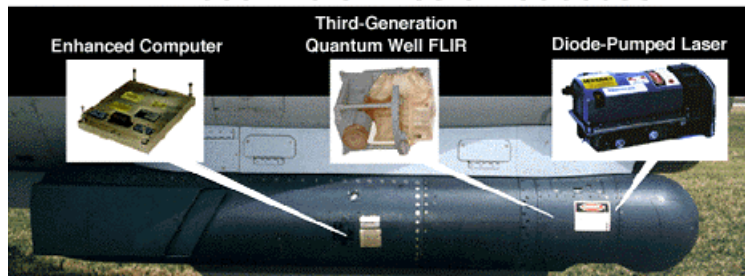
- A quantum well, third-generation forward-looking infrared (FLIR) sensor.
- A 40,000-foot altitude, diode-pumped laser.
- A more compact, more powerful computer system.

LANTIRN 2000 delivers multi-mission success. It offers LANTIRN customers around the world high-resolution FLIR imagery with extended range and reliability. Greater target detection, recognition and engagement ranges increase the probability of a first-pass kill by 50 to 60 percent. Full exploitation of the GBU-24 envelope ensures more kills per sortie at lower attrition rates. New capabilities include air-to-air, reconnaissance, theater missile defense, and battle damage assessment missions.

Thanks to ongoing research and development funding and cost of ownership improvements, Lockheed Martin has modified a targeting pod for the 21st century at minimal cost. Advances in processing, system architecture and graphical user interface make LANTIRN 2000 support equipment less costly, more reliable and easy to upgrade.

High performance and increased reliability of LANTIRN 2000 significantly reduce its cost of ownership and lower its operations and support costs by 40 percent.

LANTIRN 2000: Multi-Mission Success



Quantum Well FLIR: The World's New Standard for Imagery

The 8- to 12- micron FLIR uses quantum well technology for low-cost construction of extremely dense detector arrays. It extends weapon standoff range more than 50 percent, adding the mission flexibility of battle damage assessment and reconnaissance. Greater standoff range ensures less aircraft attrition. This third-generation FLIR is 23 percent more reliable.

Diode-Pumped Laser: Greater Range and Reliability

The diode pumped laser operates at a greater range with a smaller spot size. Its lower beam divergence, greater resolution and pointing accuracy at 40,000 feet expand the altitude and range of the targeting pod. The diode-pumped laser is 17 percent more reliable, thanks to an improved power supply, fewer parts and a cooler operating temperature. An eye-safe training laser with tactical performance and range is integrated.

Enhanced Computer System: Smaller, Lighter, More Powerful

The LANTIRN 2000 computer is smaller, weighs half as much, and uses two times less power than the computer it replaces. Throughput, memory and reliability are optimized. Software, cabling and interfaces remain the same.

LANTIRN 2000+: A Full Menu of Mission Capabilities

Lockheed Martin continues to invest in research and development to keep LANTIRN versatile, reliable and cost-effective. Additional options are:

- A laser spot tracker to improve target identification and limit collateral damage.
- A digital disk recorder for battle damage assessment and reconnaissance mission support.
automatic target recognition system to reduce pilot workload by classifying high-priority targets.
- A TV sensor, which has been successfully tested and flown, provides added capability around the clock.

LITENING for PATS



LITENING for PATS

Quick, clean, precise. That's how weapons must be delivered in combat today. Anything less than a precision strike capability has become undesirable. Now the team of Northrop Grumman and RAFAEL, with Northrop Grumman as prime contractor, make it possible for all tactical aircraft to have this capability with the innovative, new LITENING targeting pod.

More Capabilities

LITENING is a high performance, supportable, affordable system that gives modern fighters a 24 hour precision strike capability against both land and sea based targets. This NDI pod meets or exceeds all PATS requirements.

Greater Pinpoint Accuracy

Our unique on gimbal Inertial Measurement Unit (IMU) stabilizes the sensor line of sight, providing LITENING with an extremely precise tracking capability. In addition, the IMU system continuously aligns the sensors to the aircraft by communicating with the aircraft inertial navigation system while in flight, ensuring the highest degree of aircraft to pod boresight accuracy. This track and boresight accuracy enables our Laser Designator / Rangefinder to effectively designate targets for precise delivery of laser guided weapons. The Laser Designator/Rangefinder can also be used to measure range-to-target – enhancing the accuracy of conventional weapons.

FLIR Technology

LITENING's third generation Forward Looking Infrared – or FLIR – is a high resolution thermal imaging system providing an attack capability, day and night, even in the most adverse weather conditions. The FLIR provides three fields of view for a dual targeting and navigation capability – all in a single pod.

Track During Masking

When a target is obscured by clouds or a portion of the aircraft, LITENING maintains accurate track. Our Inertial Measurement Unit takes over and keeps looking at the inertial coordinate points. When the target reappears it is still in the field of view, enabling the pilot to easily re-acquire and track. This reduces pilot workload and time on station.

Better Daytime Resolution

LITENING's built in CCD-TV capability, comprised of two charged coupled device TV cameras, provides the pilot with enhanced daytime image quality and extended daytime operational ranges thereby improving weapons employment. The two camera set up allows the operator the option of switching between narrow field of view and medium field of view, depending on mission requirements.

40Kft Altitude Operation

The forward sensor head in LITENING is pressurized, eliminating high voltage arcing that occurs at high altitudes. This enables lasing up to altitudes of 40K feet, giving the pilot increased weapons delivery options.

Coordination With Friendly Forces

The laser spot tracker enables the pilot to locate targets designated by either ground-based or other airborne platforms. Our laser marker provides the capability to lase a target, illuminating it for friendly forces using night vision goggles, assisting them in battlefield awareness and management.

Growth Potential

LITENING, an NDI pod, provides excellent capabilities. We are committed to keeping it at the forefront of targeting and navigation technology. Committing our own resources, we have already begun work on enhanced capabilities to guarantee system currency well into the 21st century. LITENING comes with an additional built in feature should the Air National Guard or Air Force Reserve chose to make use of it. Our FLIR comes with a wide field of view capability that is compatible with a raster HUD for use in low level night navigation.